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THESIS

COHERENCE STUDY OF GEOMAGNETIC FLUCTUATIONS IN FREQUENCY RANGE .04 - 0.6 HZ BETWEEN REMOTE LAND SITES

by

Stephen John Anthony

December 1983

Thesis Advisor: Andrew R. Ochadlick, Jr.

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Coherence Study of Geomagnetic Fluctuations in Frequency Range .04 - 0.6 Hz Between Remote Land Sites

by

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Lieutenant, United States Navy
B.S., University of Minnesota, 1973

Submitted in partial fulfillment of the
requirements for the degree of

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December 1983

ABSTRACT

Fluctuations in the geomagnetic field were measured by three orthogonally mounted coil sensors at two land sites separated by 40 km. Computer generated voltage vs time and magnetic field vs time plots failed to reveal the presence of dominant micropulsations. A coherence study between the two sites revealed coherence values of 0.6 - 0.8 in the frequency range 0.04 - 0.6 Hz. This is compared to a coherence study completed at the Naval Air Development Center, Warminster, Pennsylvania, between land sites 24.8 km apart. The NADC coherence values are lower (0.3 - 0.6).

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I. INTRODUCTION

This thesis is part of an ongoing effort at the Naval Postgraduate School to analyze ULF geomagnetic noise and micropulsations. These variations in the geomagnetic field are of interest both from a geophysical and a military viewpoint. Applications of interest to the Navy are in the areas of magnetic detection of submarines, mine warfare and communications systems.

The specific objectives of this study were to install and operate a simultaneous data collection system at two separated land sites, to modify and adapt previously developed software for data analysis and to obtain spectral coherences between the two sites for background noise and/or micropulsations.

A coherence study of background noise with background noise, of micropulsation with micropulsation and of background noise with micropulsation between the two sites should further the understanding of the types and extent of the sources that produce these fluctuations.

The data collection sites were separated by a distance of 40 km (see Appendix A). One site was at La Mesa Village, near the Naval Postgraduate School campus, while the other was at the Chew's Ridge fire lookout. The latter was chosen for its remoteness from the local power grid.

II. BACKGROUND

A. MICROPULSATIONS

The frequency spectrum of the geomagnetic field observed on or near the earth's surface has a number of well defined peaks, corresponding to categories of regular geomagnetic micropulsations, as shown in Figure 2.1. These micropulsations are designated as Pc1, Pc2, ... Pc5.

Another category of micropulsations encountered is irregular pulsations. Unlike regular Pc micropulsations, which have relatively well defined frequencies, the Pi micropulsation consists of a spectral band of noise.

The source of these micropulsations appears to be magneto-hydrodynamic resonances in the earth's magnetosphere (Pc2 - Pc5), ion cyclotron wave-particle interaction in the magnetosphere (Pc1) and ionospheric currents perturbed by conductivity variations (Pi). References 1 and 2 give more detailed explanations of these mechanisms. Micropulsations are classified as follows:

1. Pc1: (0.2 - 5 Hz frequency)

Known as "Pearls", these micropulsations are generated by the cyclotron instability of energetic protons. They have been positively correlated with solar disturbances and occur during daylight hours in the auroral zone and

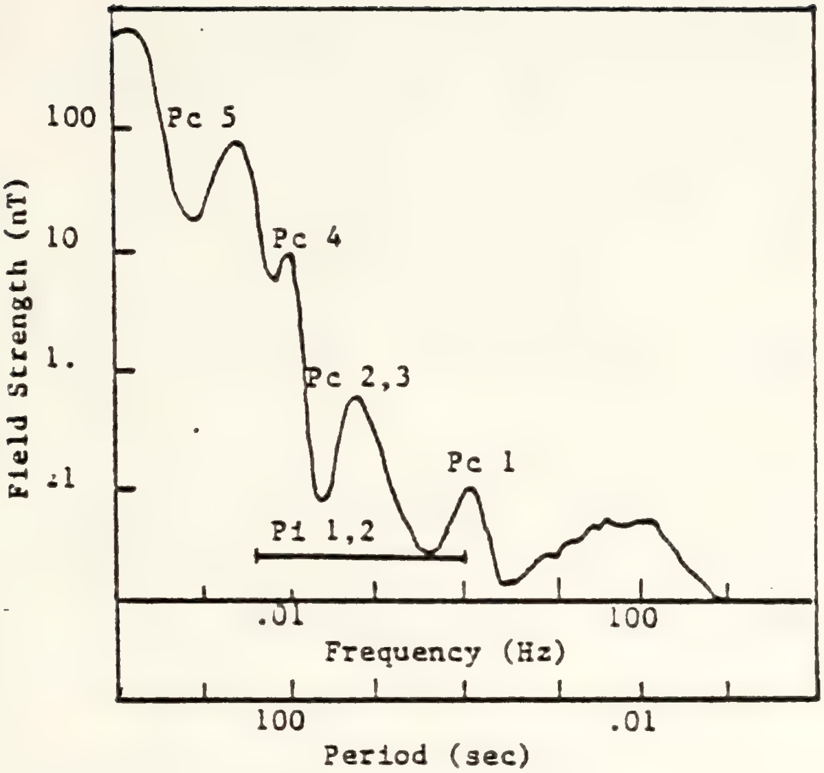

Figure 2.1 Field Strength of Micropulsations.

during night and early morning hours in the midlatitudes. Typical amplitudes are 0.05 - 0.1 nanotesla.

2. Pc2: (0.1 - 0.2 Hz frequency)

This is a diurnal phenomenon that shows some positive correlations with solar activity and the seasons. They usually decrease in their period as magnetic activity increases. Their average amplitude is 0.1 - 1 nanotesla.

3. Pc3: (0.022 - 0.1 Hz frequency)

These are similar to Pc2 pulsations except for the frequency range.

4. Pc4: (6.7 - 22 mHz frequency)

Sunspot activity appears to have an effect on Pc4 pulsations. Their frequency varies with the season and they have an average amplitude of 5 - 10 nanotesla.

5. Pc5: (1.7 - 6.7 mHz frequency)

These large scale pulsations occur during morning and evening with amplitudes of 10 - 100 nanotesla. Their duration shows a strong geomagnetic latitude dependence.

6. Pil: (0.025 - 1 Hz frequency)

These pulsations usually occur at night and early morning and vary in intensity from 0.01 - 0.1 nanotesla. They demonstrate a positive correlation with auroral disturbances.

7. Pi2: (6.7 - 25 mHz frequency)

The amplitude of these pulsations ranges from 1 - 5 nanotesla. They usually occur during early morning hours but may continue throughout the night. The frequencies of these pulsations increase with increasing magnetic activity.

Geomagnetic micropulsations can be distinguished from the general noise background of the geomagnetic field. The micropulsation events rise out of the ever present background activity, reach an amplitude that can be large in comparison to the background level, and then finally disappear into the background. The Pc4 and Pc5 pulsations can last several hours. However, the Pc1 - Pc3 and Pi micropulsations have a maximum duration of approximately one hour but may last only a few minutes.

B. GEOMAGNETIC BACKGROUND NOISE

It has been speculated that the primary source of the geomagnetic background noise is fluctuations in the interplanetary magnetic field [Ref. 3]. If so, a source of such large spatial extent implies that the amplitude of the background noise may be less variable over the surface of the earth than the more locally generated micropulsations, and one could expect considerable spatial coherency of the background noise over the earth's surface.

David and Heirtzler [Ref. 4] studied the coherence of geomagnetic variations between two stations up to 550 km apart. The geomagnetic variations were separated into a background noise component and a micropulsation component. When two different micropulsation types occurred simultaneously, they were found to be incoherent with one another and with the background noise. It would thus appear that independent generation mechanisms exist for the background noise component and for micropulsations of different types. Also, the background component showed association with the solar quiet day magnetic variation (Sq). In particular, the spectrum amplitude of the background component increased as the strength of Sq increased.

III. DATA COLLECTION SYSTEM

A. EQUIPMENT DESCRIPTION

The system used at both the Chew's Ridge and La Mesa Village sites is shown in Figure 3.1. The major components are:

(1) Coil sensors

(2) Preamplifiers

(3) Signal conditioner

(4) Pulse Code Modulation (PCM) encoder

(5) WWV radio receiver

(6) Tape recorder

(7) Power source

For a geographical description of the two sites, see Appendix A.

1. Coil Sensors

Each coil is continuously wound with 5460 turns of 18 gauge copper magnet wire. It has an internal resistance of 9.31 Henries. At each site, the three coils were mounted orthogonally, with the x coil oriented towards magnetic north, the y coil towards magnetic east and the z coil vertically downwards.

2. Preamplifiers

The preamplifiers are model 13-10A low noise amplifiers manufactured by Dr. Allen Phillips of SRI

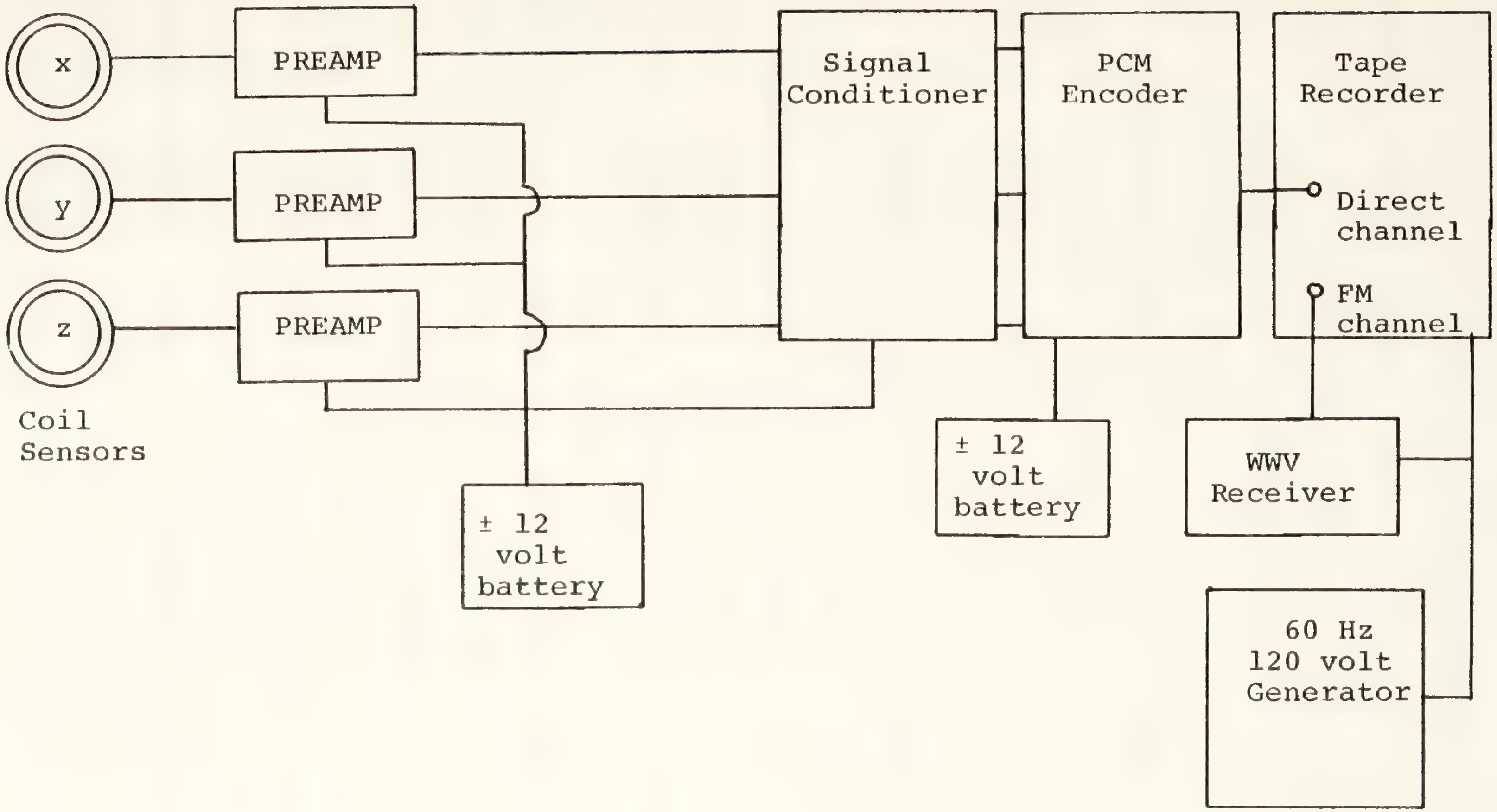

Figure 3.1 Block Diagram of Data Collection System.

International. The overall power gain is 60 dB for inputs less than 2.5 mV. A final stage low pass filter which provides a sharp cutoff at 20 Hz is provided. Each preamplifier has a DC offset potentiometer which must be adjusted to provide the correct zero-level at the output.

3. Signal Conditioner

The signal conditioner receives the analog signals from the preamplifiers, amplifies them by 30 dB and limits them to an amplitude of 7.5 volts.

4. PCM Encoder

The pulse code modulation (PCM) was designed and manufactured by Dr. Robert Lowe of Lowecom Incorporated and of the Scripps Institute of Oceanography in La Jolla, California. The encoder features 15 channel analog input capability with selectable sample rates of 2^n samples per second, where n is an integer value of 3 to 7. For the purposes of this thesis only 3 of the input channels were utilized (1, 2 and 3 for the x, y and z channels, respectively), and a sample rate of 64 samples per second was chosen to ensure adequate measurement of frequencies below 0.1 Hz. The encoder samples the analog signal from each channel at a rate of 64 Hz and assigns a pulse coded digital word with a decimal value between 0 and 4096 to each sample, corresponding to an amplitude of -5 to +5 volts. The output data is organized into frames, each

frame headed by a synch code word which is followed sequentially by the pulse coded samples from input channels 1 through 15. The synch code word is a pulse coded digital word with a decimal value of between 0 and 4096. This word is preselected and hardwired on the encoder circuit board. Reference F explains the PCM system in more detail.

5. WWV Radio Receiver

In order to ensure that the data from the two sites was analyzed simultaneously, an R-1051 B/URR radio receiver was used to monitor the WWV Universal Time broadcast at 20 MHz at each site. The broadcast gives the Universal Time at each minute by voice with each second marked by a tone.

6. Tape Recorder

Hewlett-Packard HP3964A/3968A tape recorders were used to record the PCM data and WWV broadcast on analog magnetic tape. The output from the PCM encoder was recorded on a direct channel (100 - 16000 Hz frequency response) and the WWV time signal was recorded on an FM channel.

7. Power Source

At the Chew's Ridge site the power source used was a 3500 watt, 60 Hz, 120 volt, gasoline powered, portable generator. The separation between the sensor coils and instrumentation was about 100 feet, and between the sensor coils and portable generator approximately 250 feet. Commercial 60 Hz power was available at the La Mesa Village site.

The preamplifiers, signal conditioners and PCM encoders were powered by rechargeable 18 amp-hour batteries (plus and minus 12 volts and ground).

B. PCM TO DIGITAL CONVERSION

The PCM data recorded on analog tape is played back into a PCM decoder which converts it to digital data. The digital data is recorded in 9-track, 800 bits per inch computer tape for subsequent analysis on the IBM 3033 mainframe computer. Appendix B contains a step-by-step procedure for the decoding process.

By listening to the FM channel carrying the WWV time signal over a speaker, the point on the analog PCM tape where it is desired to begin and stop the decoding process may be precisely determined. In this manner it is possible to obtain time synchronized digital computer tapes of data from the two sites.

IV. COMPUTER SOFTWARE

The computer programs used to analyze the data are written in Fortran IV programming language and are briefly discussed below. These programs are listed in Appendices C - G.

A. PROGRAM VOLTR

The VOLTR program reads data from a digital computer tape and generates a voltage vs time plot for each orthogonal axis. The data is read from the tape in blocks of 8192 frames (128 seconds) by the subroutine RD. This data, which is in integer form between 0 to 4096, is then normalized to represent voltages between ± 5 volts. The amount of data plotted is an integer increment of 128 seconds, the integer being from 1 to 8 and specified by the user.

B. PROGRAM VODIG

This program applies a 144 point double running average and a .04 - 0.6 Hz digital filter to the rough voltage and generates filtered voltage vs time plots for each axis. The digital filter simulates the pass band of an AN/SQ-81 magnetometer and was developed by Mike Huete of the Naval Postgraduate School. Reference 5 explains the filter in detail. The double running average smooths out any large noise "spikes" that may cause an unnatural oscillatory

response in the digital filters. It also acts as a low pass filter, removing frequencies greater than approximately 1 Hz.

C. MASS STORAGE PROGRAM

In order to compare simultaneous data from two different computer tapes, the data is read from one tape (La Mesa Village), normalized to voltage values and stored in the IBM 3033 Mass Storage System, where it is available for future recall.

D. PROGRAM MAGFLD

This program generates magnetic field vs time plots. The digital data is read from the computer tape and normalized to voltage values. A Fourier transform is performed on the data to enter frequency space. At this point the system transfer function, which converts the data from voltage to magnetic field values, is applied. References 6 and 8 detail the procedures used to determine the transfer function for each coil sensor-amplifier subsystem. After the transfer function has been applied, a second Fourier transform is performed to return the data to time space. A 144 point double running average is then applied to the magnetic field data to remove frequencies above about 1 Hz.

B. PROGRAM COHER

This program calculates the spectral coherence of the total field between the two sites and the power spectral densities of the total field at each site. The La Mesa Village data previously stored in the Mass Storage System is recalled, the corresponding Chew's Ridge data is read from a computer tape, and the two data sets manipulated simultaneously.

Referring to Figure 4.1, the total field was calculated as

$$\text{total field} = x\cos\theta_d + z\sin\theta_d$$

where θ_d is the magnetic dip angle, which in the Monterey area is 60°.

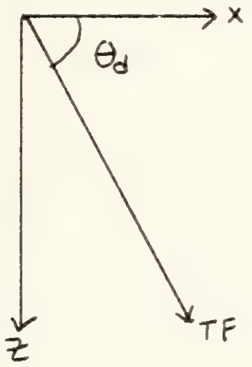

Figure 4.1 Total Field Diagram

The coherence between two signals a(t) and b(t) is

$$\text{coherence} = \frac{a(t)\circ b(t)}{\sqrt{a(t)\circ a(t)}\ \sqrt{b(t)\circ b(t)}} = \frac{A(F)B^*(F)}{\sqrt{a(F)A^*(F)}\ \sqrt{B(F)B^*(F)}}$$

where '$\circ$' indicates the correlation separation, '*' indicates

the complex conjugate is taken and A(F) and B(F) are the Fourier transforms of a(t) and b(t) , respectively.

In the program, a Fourier transform of the data into frequency space was performed and an average of 20 blocks of data (128 seconds per block) was taken to obtain the final coherence values.

V. TESTING OF PCM SYSTEM AND SOFTWARE

In order to ensure that the PCM system and VOLTR program faithfully reproduced the input signals, sinusoidal, triangular and square waves were input to the PCM encoder by a Wavetek signal generator, as shown in Figure 5.1, and the PCM signal recorded on analog tape. The signal generator output was also monitored by a chart recorder and voltmeter. The analog tape was then decoded and voltage vs time plots were generated by the VOLTR program.

Table 5.1 shows the relationship between the amplitude of the signal generator output and the amplitude of the VOLTR plots (Figure 5.2) at various frequencies for the sinusoidal signal.

As can be seen from Table 5.1, the error between the chart record and the computer plot is less than two percent. Similar results were obtained for the triangular and square wave on all three channels.

Extensive testing of the Mass Storage program, and the digital filter algorithm employed in the VODIG program, is documented in References [6] and [7], respectively.

The program COHER was tested by analyzing a section of data against itself. Data from a computer tape was read into the mass storage system by the Mass Storage program. The same section of data was read from the tape by

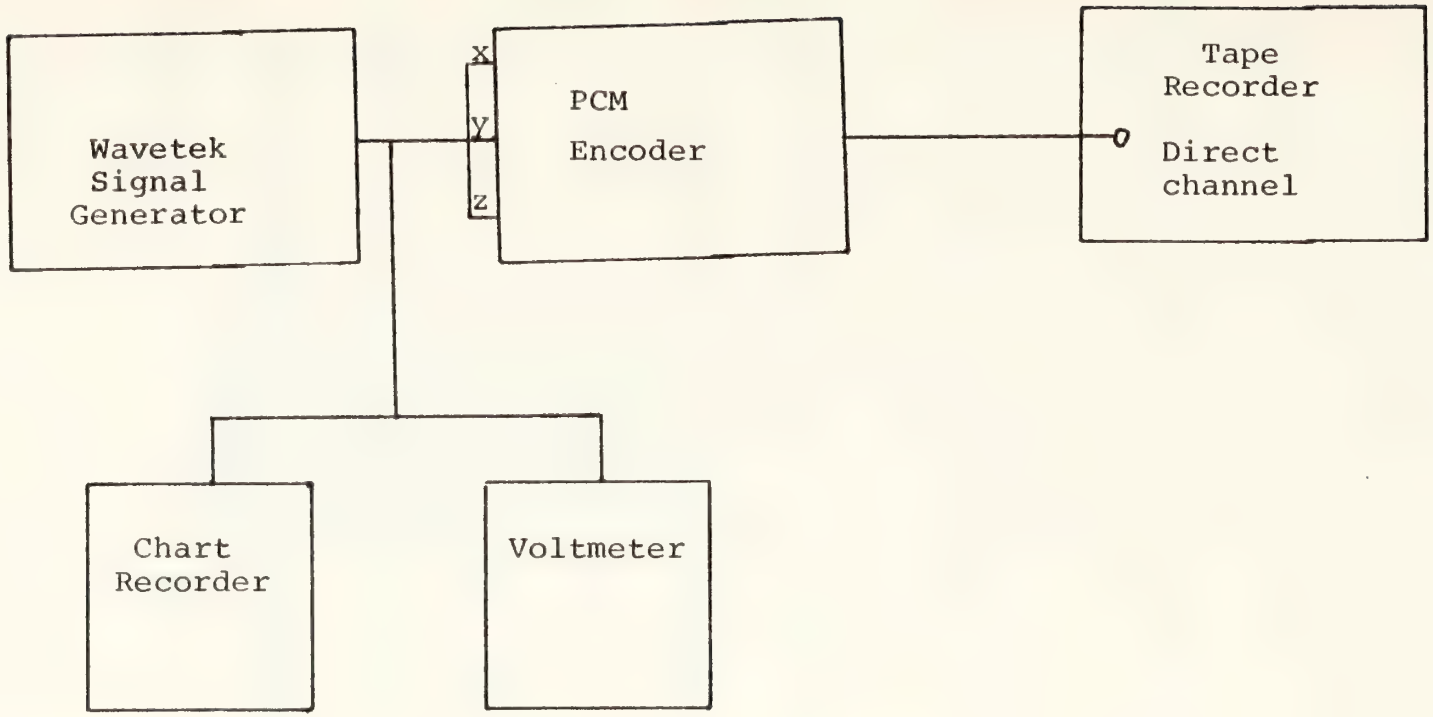

Figure 5.1 Block Diagram of Test System.

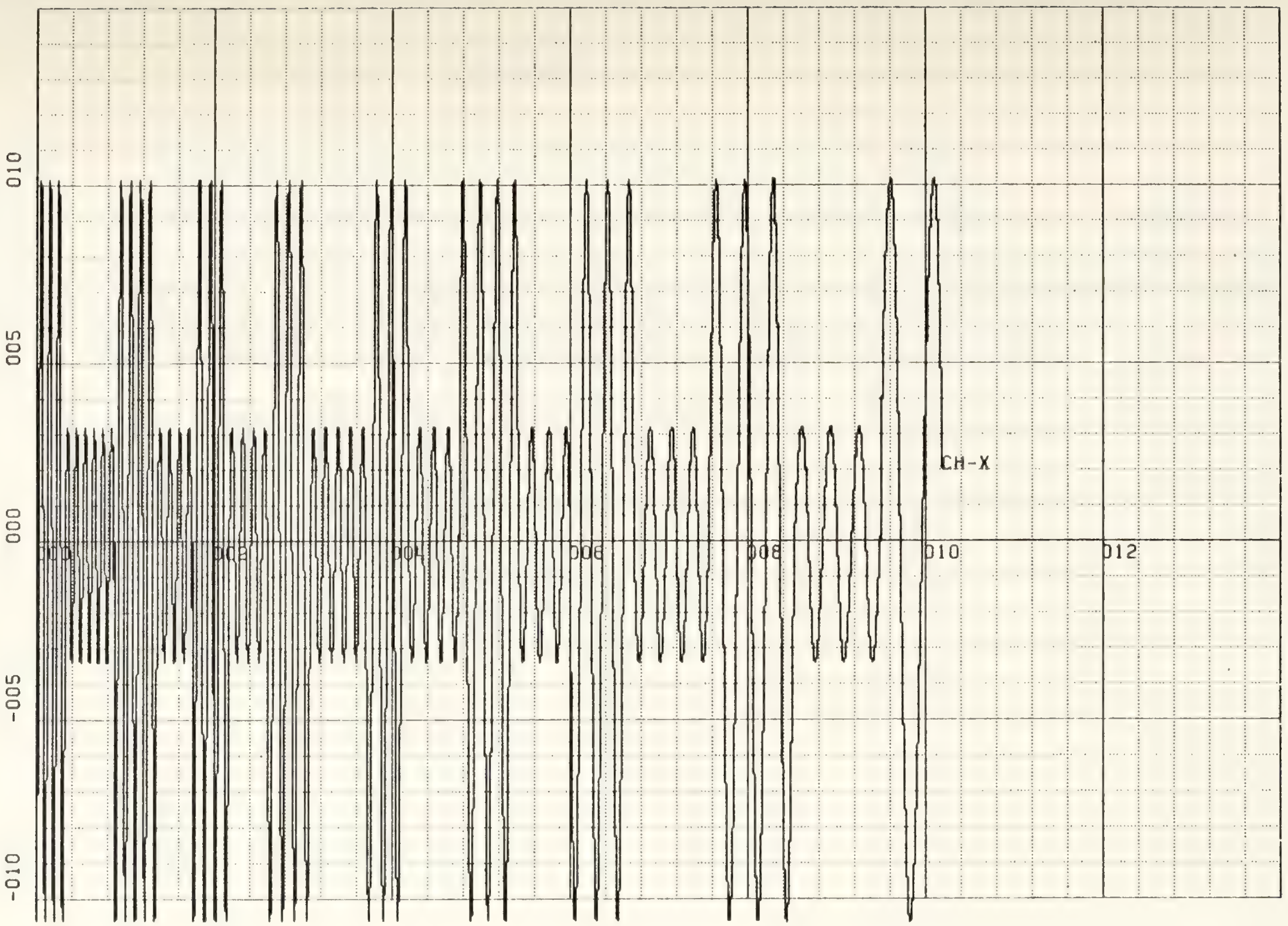

Figure 5.2 Test Voltage, Voltage (0.5 volts/inch) vs Time (200 seconds/ inch).

TABLE 5.1

MEASURED AND COMPUTER GENERATED VOLTAGE VALUES

Freq (Hz)	Chart Record (volts)		Computer Plot volts		Error %	
	Large Amplitude Oscillations	Small Amplitude Oscillations	Large Amplitude Oscillations	Small Amplitude Oscillations	Large	Small
0.10	2.10 ± .01	0.67 ± .01	2.08 ± .01	0.66 ± .01	1.0	1.5
0.09	2.09	0.67	2.08	0.66	0.5	1.5
0.08	2.09	0.67	2.08	0.66	0.5	1.5
0.07	2.09	0.67	2.08	0.66	0.5	1.5
0.06	2.09	0.67	2.08	0.66	0.5	1.5
0.05	2.10	0.67	2.08	0.66	1.0	1.5
0.04	2.10	0.67	2.08	0.66	1.0	1.5
0.03	2.10	0.67	2.08	0.66	1.0	1.5
0.02	2.11	0.67	2.08	0.66	1.4	1.5
0.01	2.11	0.67	2.08	0.66	1.4	1.5

the COHER program and analyzed with the data recalled from mass storage. The COHER program generated a coherence vs frequency of 1 as expected (Figure 5.3).

Reference 8 mentioned the presence of "cross-talk" between the channels of the PCM encoder. This was noticed on computer generated plots on a channel whose input jack was left open while making measurements at a field site. To test for "cross-talk", a signal from the Wavetek signal generator was fed into all three channels of the PCM encoder, as in Figure 5.1. . One of the channels was disconnected from the Wavetek and the input jack left open. Then the input jack was grounded, and then finally the Wavetek signal was reconnected. Figure 5.4 is a rough voltage vs time plot for the sequence. It can be seen that while the input jack was open a signal did appear on the channel but disappeared while the input jack was grounded. The "cross-talk" mentioned in Reference 8 was actually the open input jack acting as a "pickup" antenna.

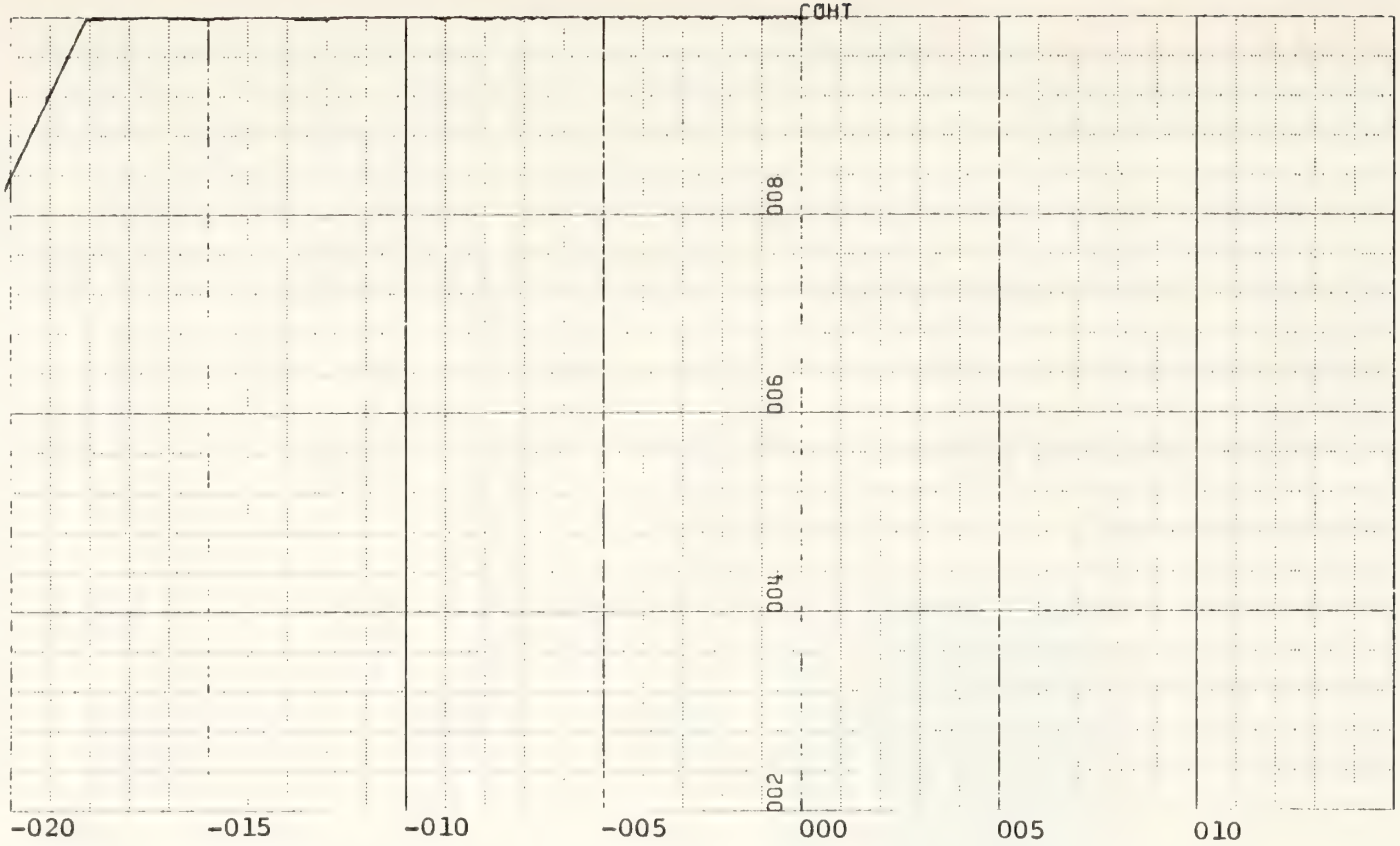

Figure 5.3 Coherence Test, Coherence (0.2 units/inch) vs Log Frequency (0.5 log Hz/inch).

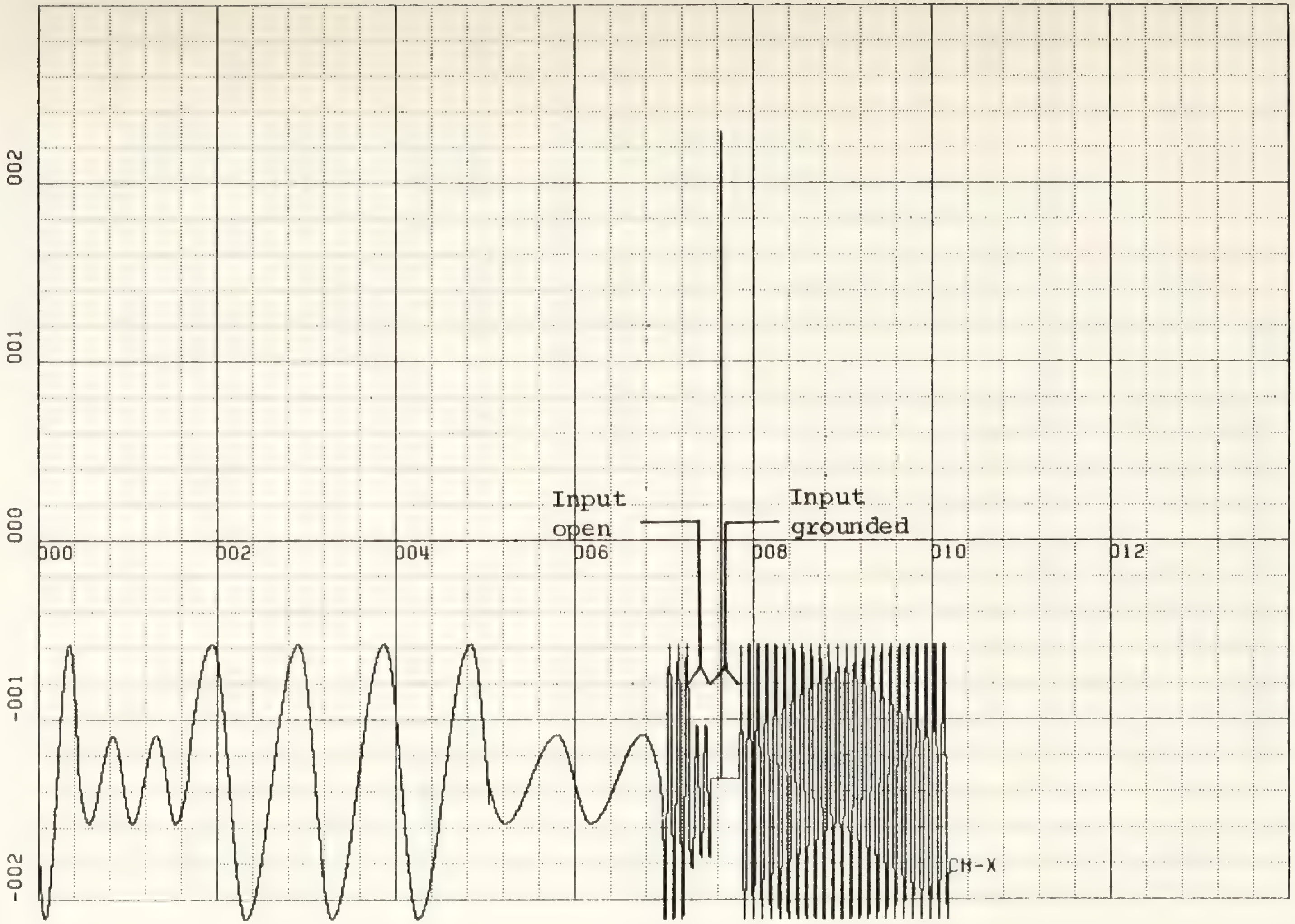

Figure 5.4 Test Voltage, Voltage (1 volts/inch) vs Time (200 seconds/ inch).

VI. EXPERIMENTAL RESULTS

Data was taken on 4 August 1983 between 1300 and 1845 local time. Beginning and ending the recording of the analog tapes was coordinated between the two sites over PRC-77 radios. Since it proved difficult to communicate between the two sites directly (because of intervening hills), a person using a radio with a large whip antenna at the Naval Postgraduate School directed the simultaneous starting and ending of data recording at the two sites.

On the voltage and magnetic field plots, the units labeled on the vertical scale are arbitrary and only the peak-to-peak variations should be considered.

A. ROUGH VOLTAGE PLOTS

Figures 6.1 - 6.6 show the rough voltage plots for the La Mesa Village site. These signals are totally obscured by 60 Hz noise. Figures 6.7 - 6.12 show the Chew's Ridge rough voltage plots. Here the 60 Hz noise is a site as remote as Chew's Ridge (to escape the 60 Hz power grid) is thus justified.

B. FILTERED VOLTAGE PLOTS

Figures 6.13 - 6.30 show typical filtered voltage vs time plots for both sites. Visual inspection failed to

reveal the presence of any large amplitude micropulsations or of any clear one-to-one correspondence in simultaneous sections of data.

C. MAGNETIC FIELD PLOTS

Figures 6.31 - 6.45 show typical magnetic field vs time plots for both sites. Magnetic field variations at the La Mesa site are approximately one nanotesla; variations at the Chew's Ridge site are slightly greater, 2 - 4 nanotesla.

D. COHERENCE PLOTS

Figures 6.46 - 6.57 show coherence vs frequency plots for individual axes and for the total field. The coherence generally has values between 0.6 - 0.8 indicating a moderate degree of commonality in the geomagnetic variations at the two sites.

These coherence plots can be compared with coherence vs frequency plots generated from background geomagnetic variation data taken at the Naval Air Development Center in 1979. The separation between the NADC data collection sites was 24.8 km. Figures 6.58 - 6.60 show these plots. In general, the coherence values from the NADC data are less than the coherence values found in our measurements. However, the amplitudes of geomagnetic variations are

probably influenced by factors such as the state of the ionosphere and magnetosphere and the stage of the solar cycle.

The NADC data was averaged over a period of two hours while our data was averaged over a period of 40 minutes.

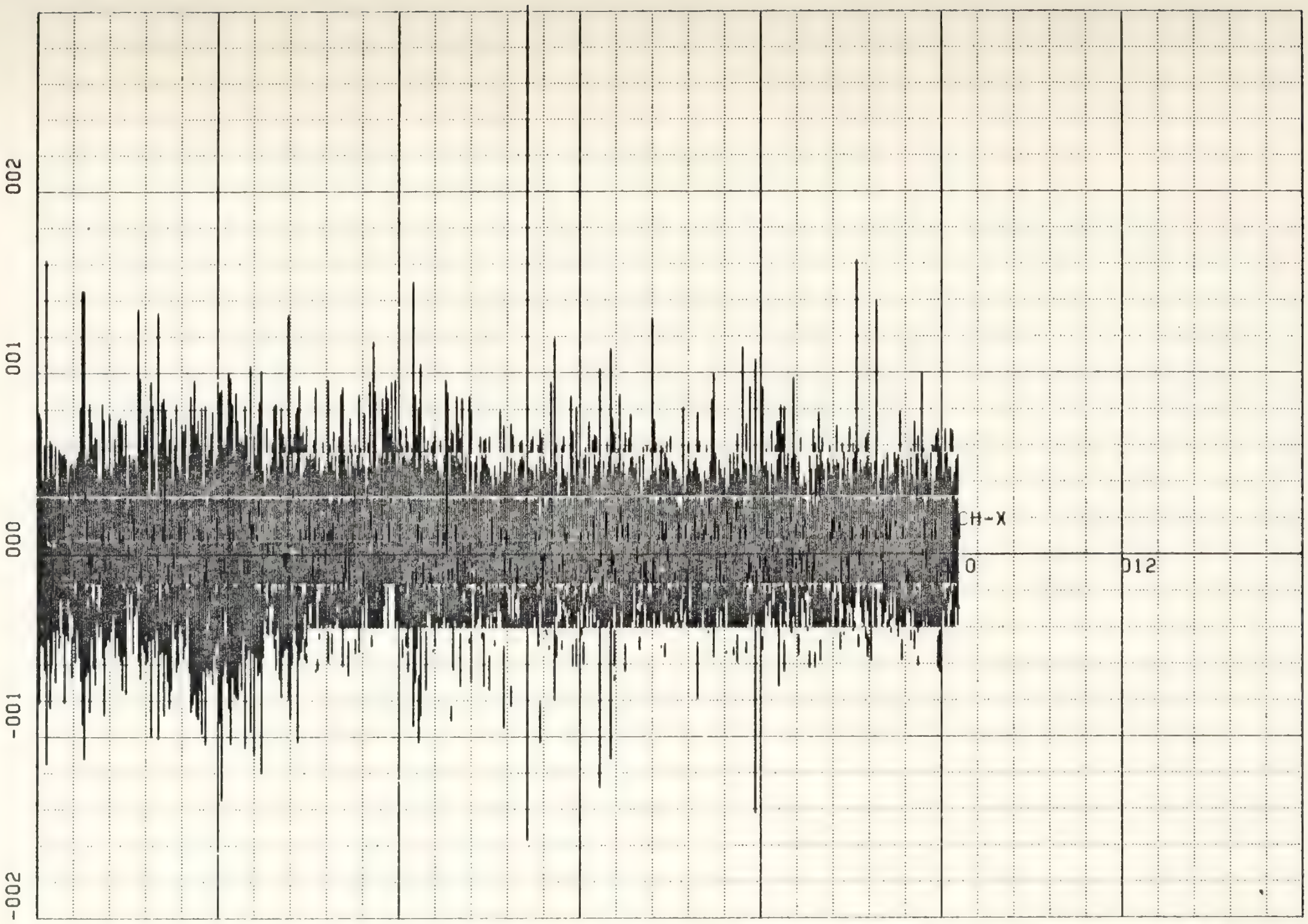

Figure 6.1 X Coil Voltage

La Mesa Village, 1359 - 1416 Local

Voltage (1 volt/inch) vs Time (200 seconds/inch).

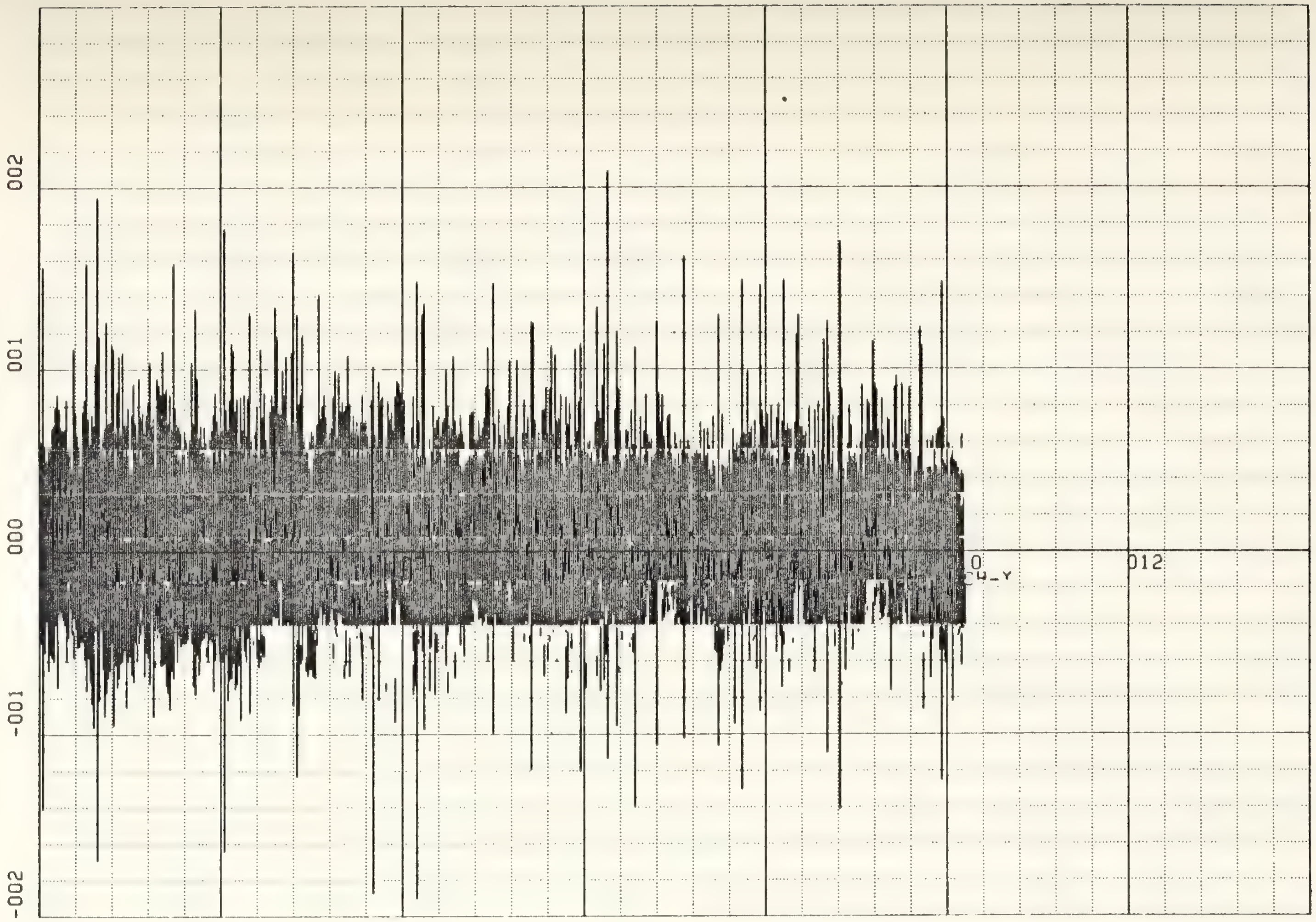

Figure 6.2 Y Coil Voltage

La Mesa Village, 1359 - 1416 Local

Voltage (1 volt/inch) vs Time (200 seconds/inch).

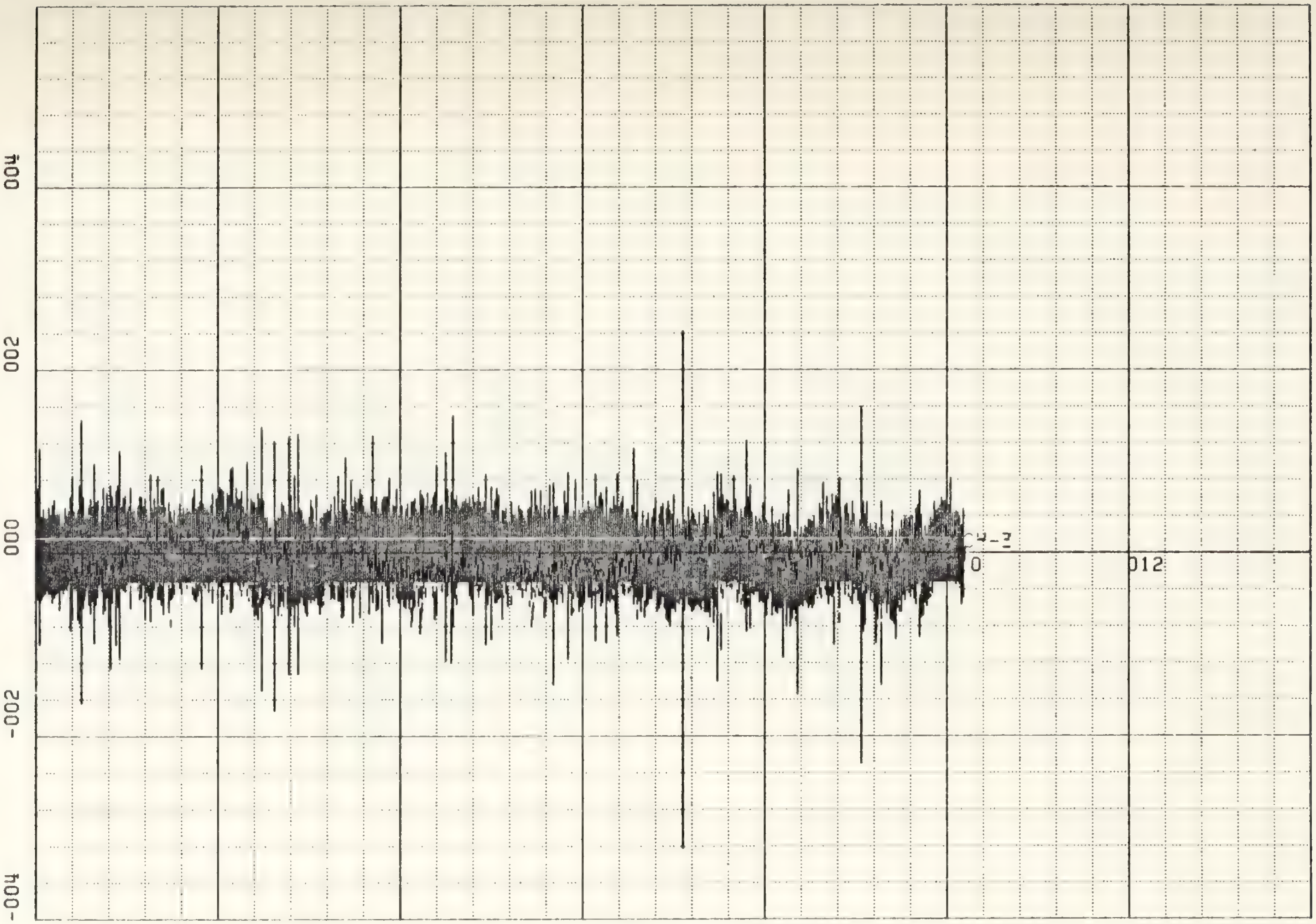

Figure 6.3 Z Coil Voltage

La Mesa Village, 1359 - 1416 Local

Voltage (2 volts/inch) vs Time (200 seconds/inch).

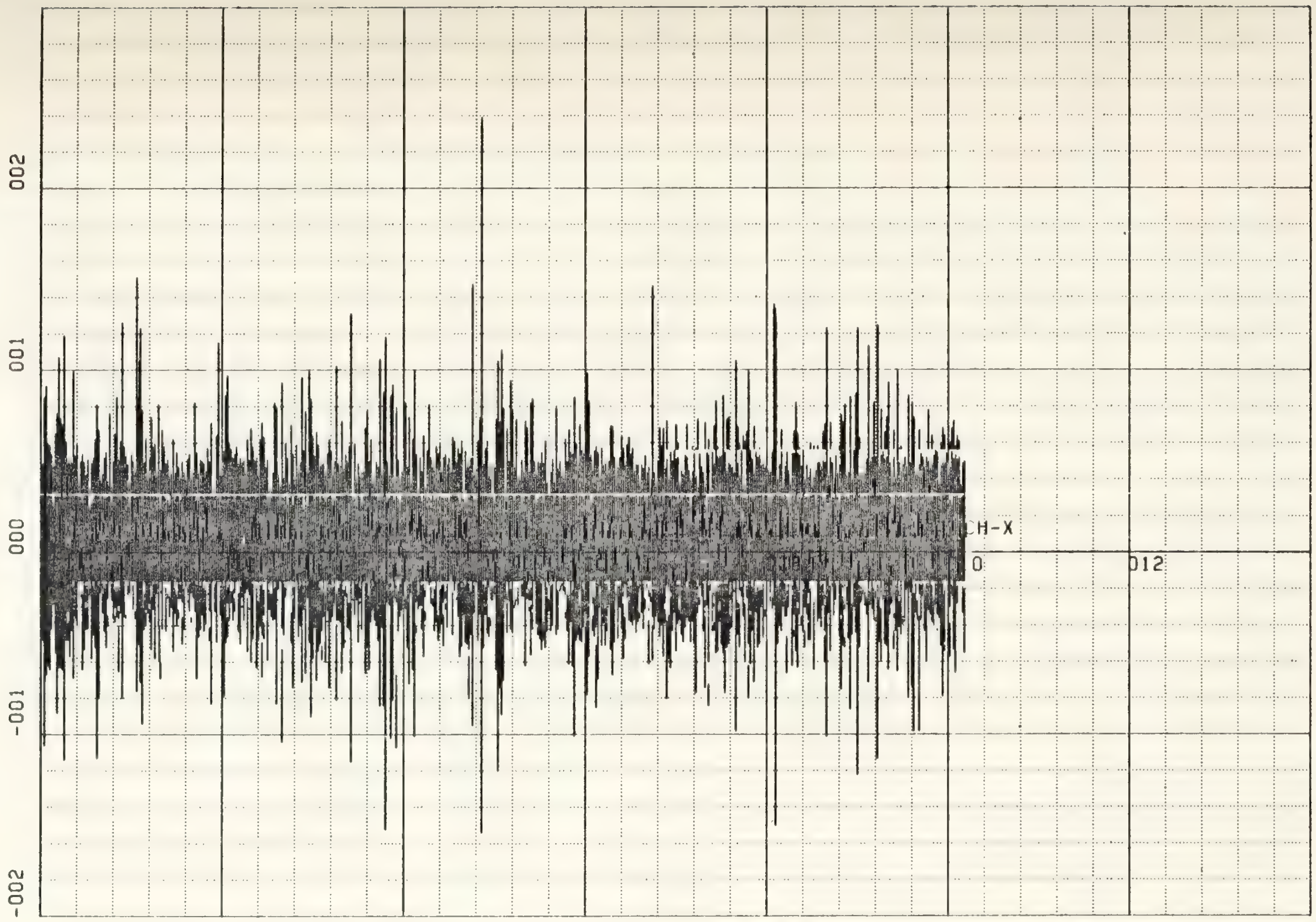

Figure 6.4 X Coil Voltage

La Mesa Village, 1500 - 1517 Local

Voltage (1 volt/inch) vs Time (200 seconds/inch).

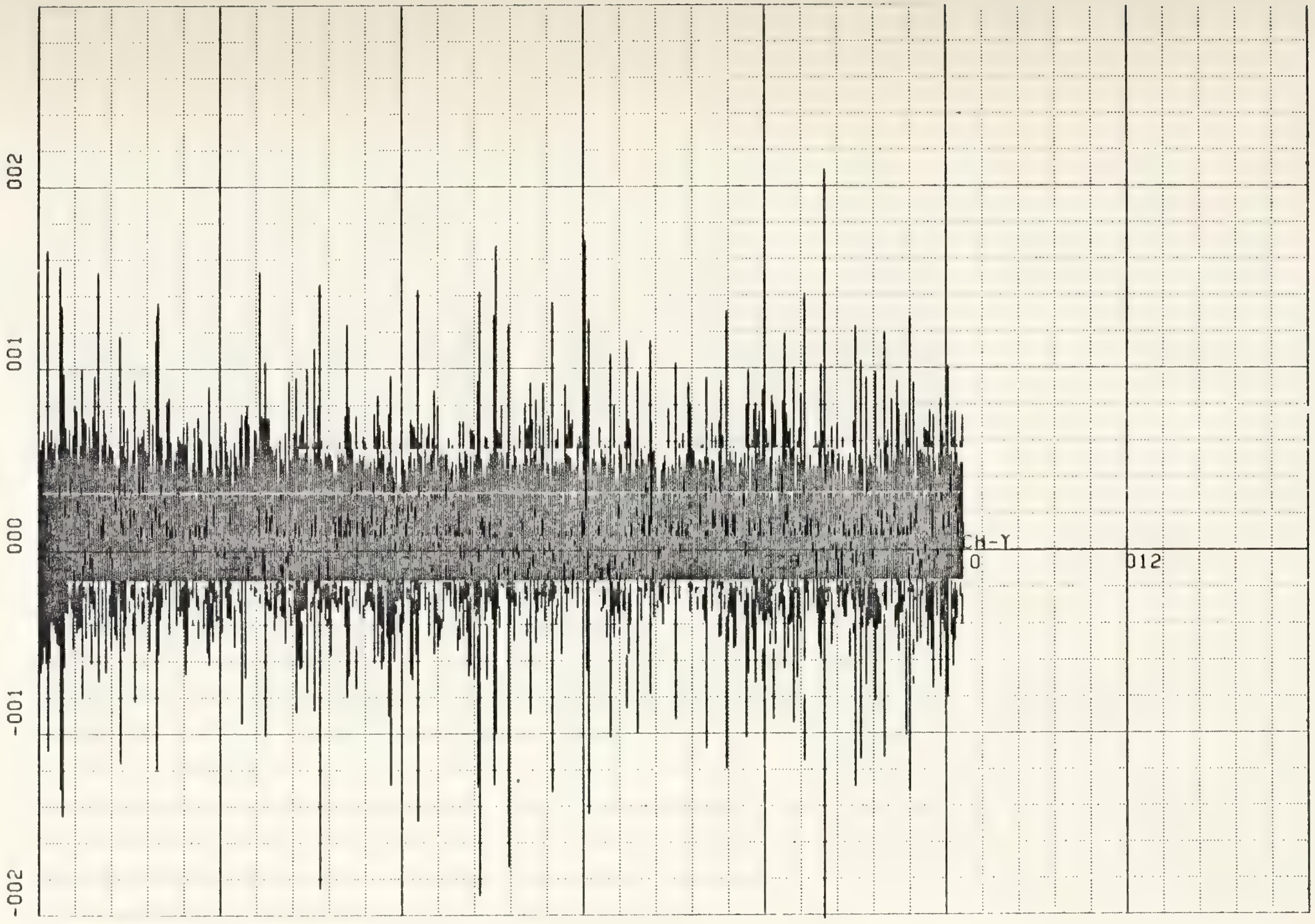

Figure 6.5 Y Coil Voltage

La Mesa Village, 1500 - 1517 Local

Voltage (1 volt/inch) vs Time (200 seconds/inch).

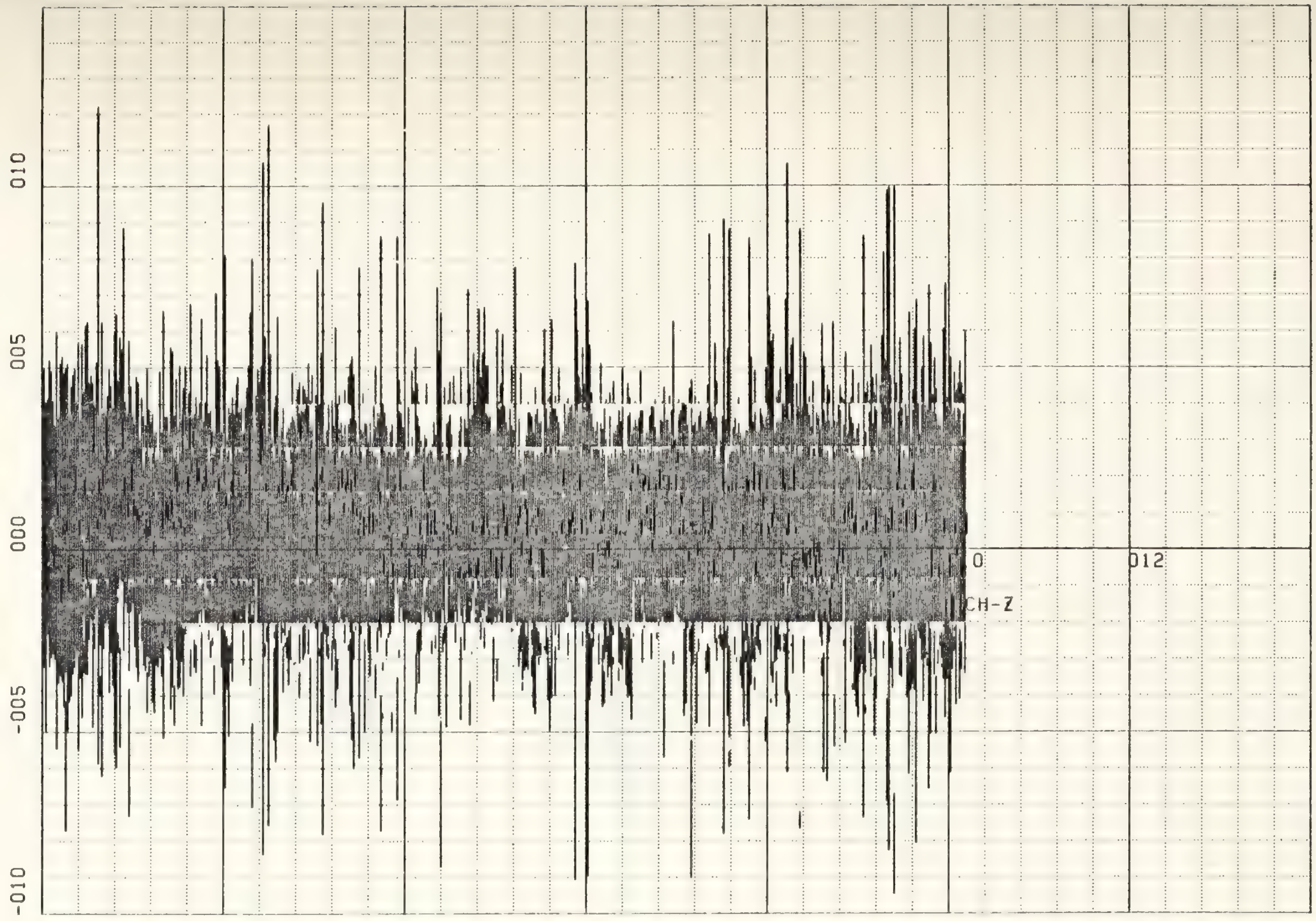

Figure 6.6 Z Coil Voltage

La Mesa Village, 1500 - 1517 Local

Voltage (0.5 volts/inch) vs Time (200 seconds/inch).

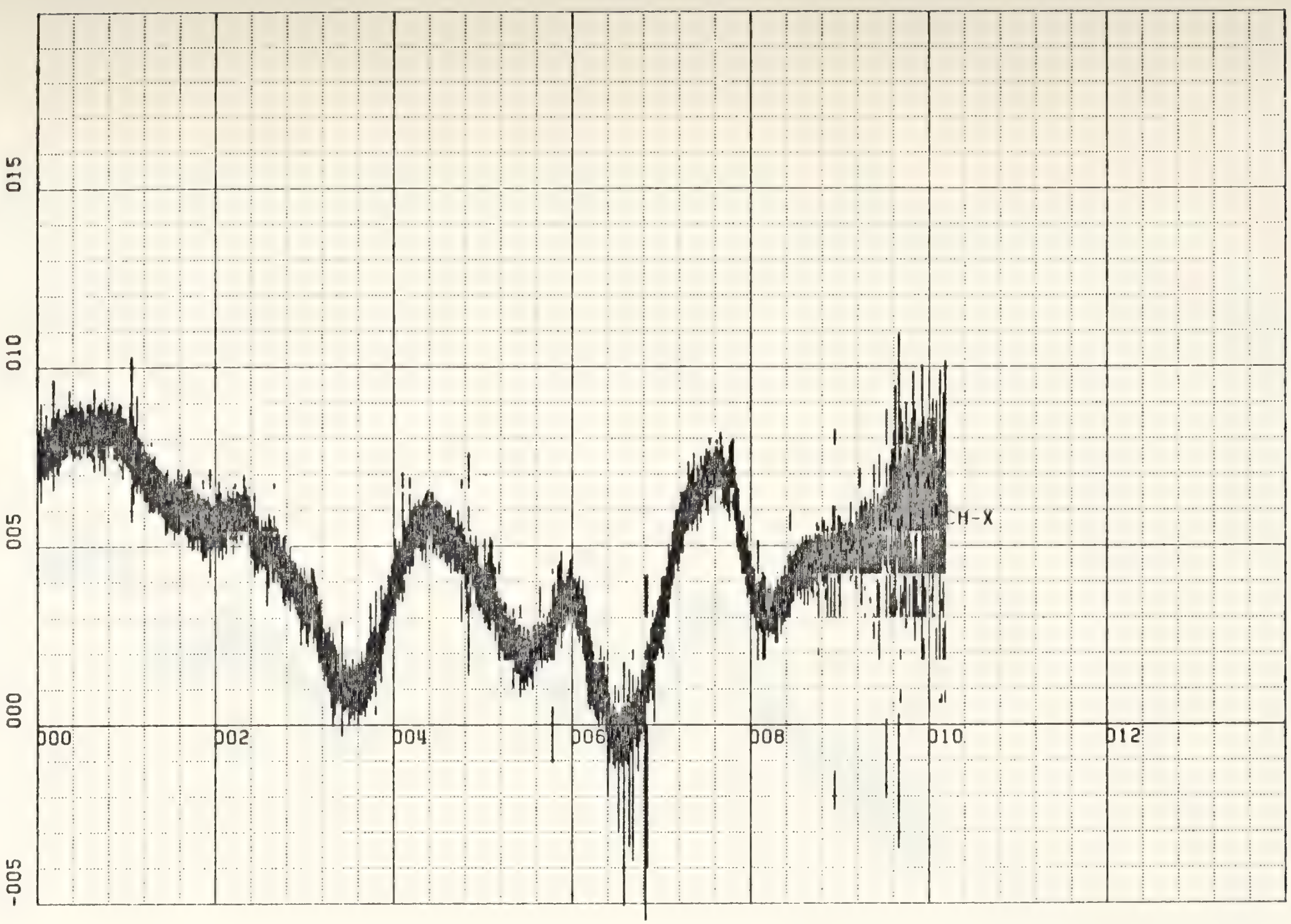

Figure 6.7 X Coil Voltage

Chew's Ridge, 1500 - 1517 Local

Voltage (0.5 volts/inch) vs Time (200 seconds/inch).

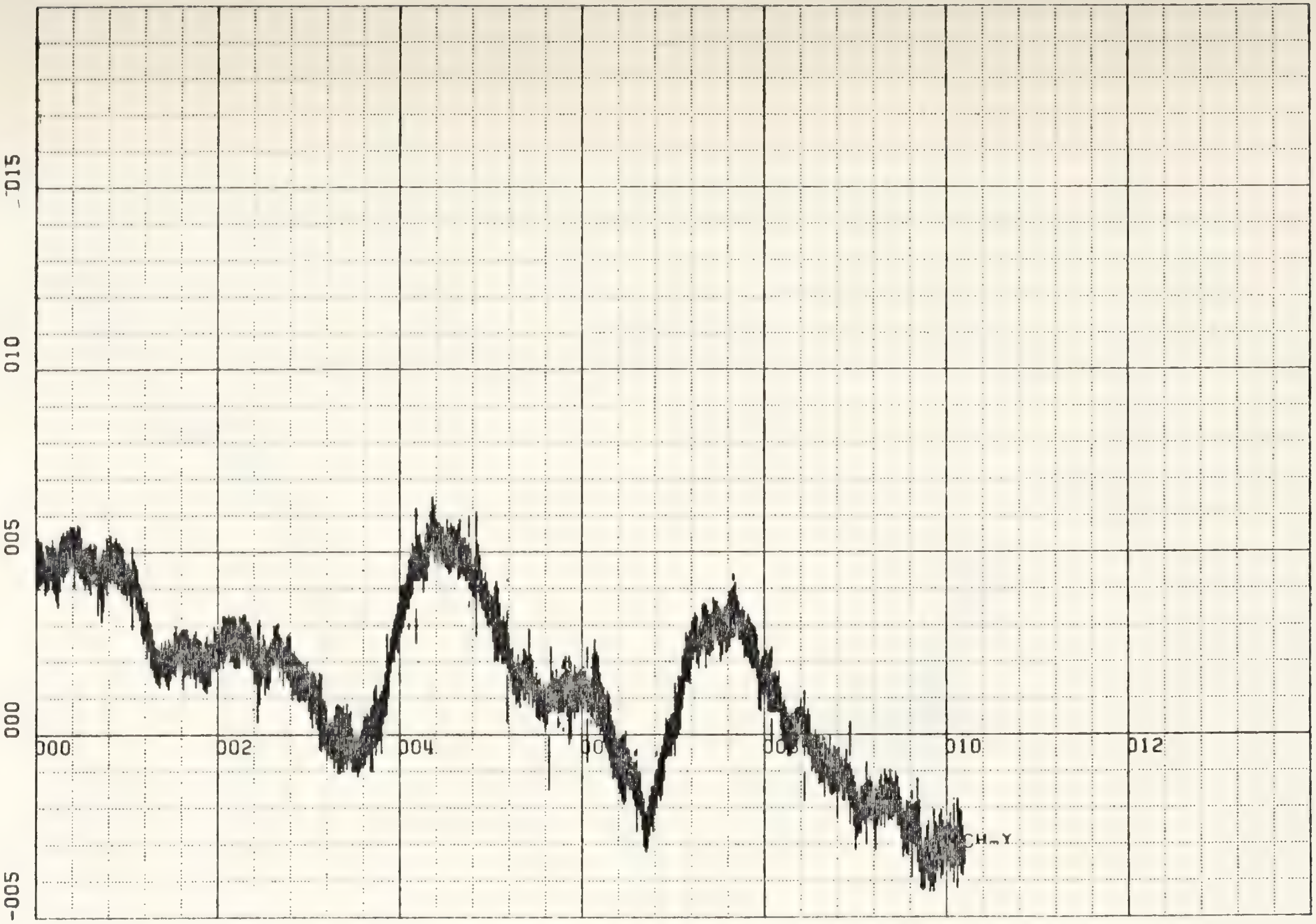

Figure 6.8 Y Coil Voltage

Chew's Ridge, 1500 - 1517 Local

Voltage (0.5 volts/inch) vs Time (200 seconds/inch).

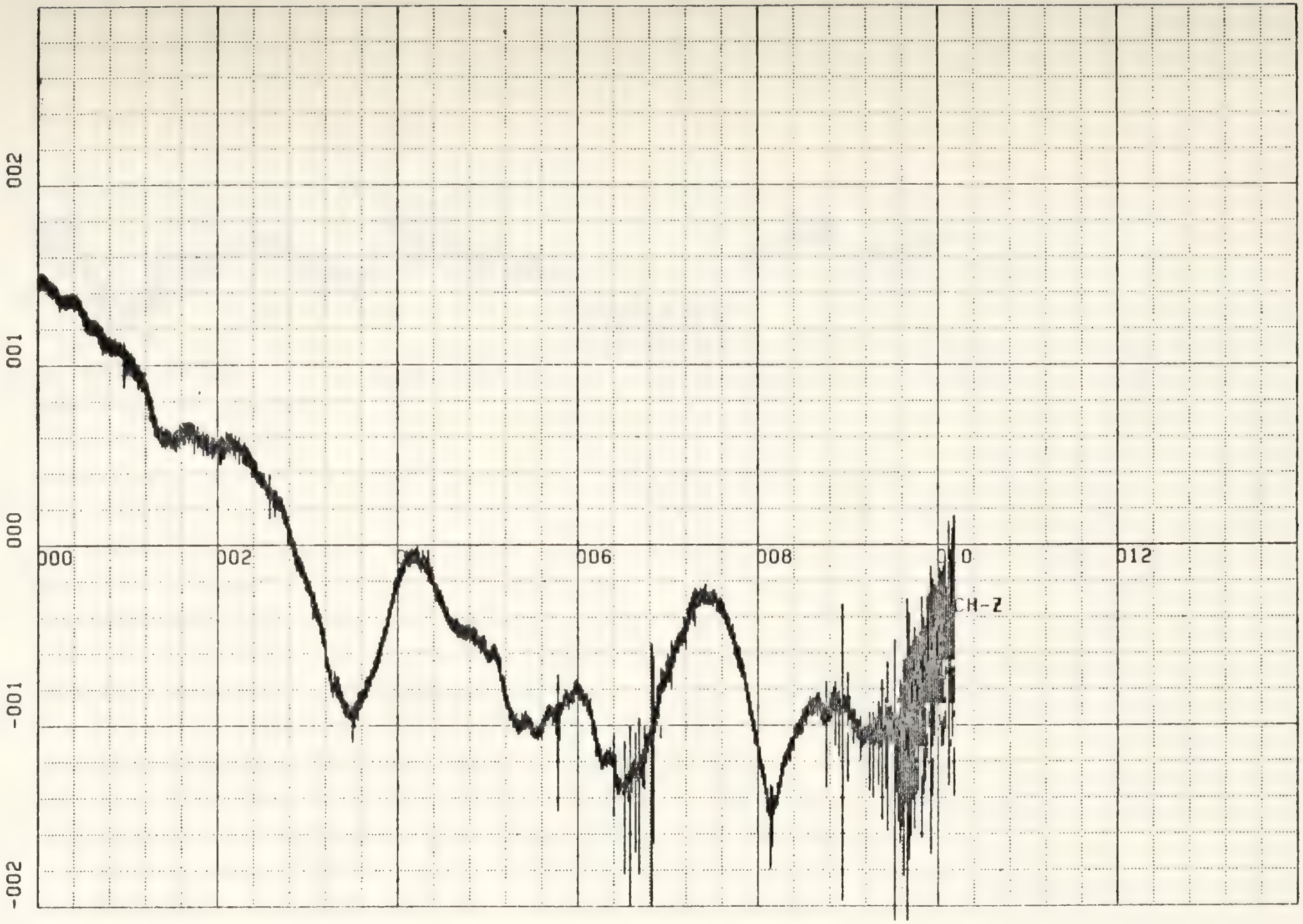

Figure 6.9 Z Coil Voltage

Chew's Ridge, 1500 - 1517 Local

Voltage (1 volt/inch) vs Time (200 seconds/inch).

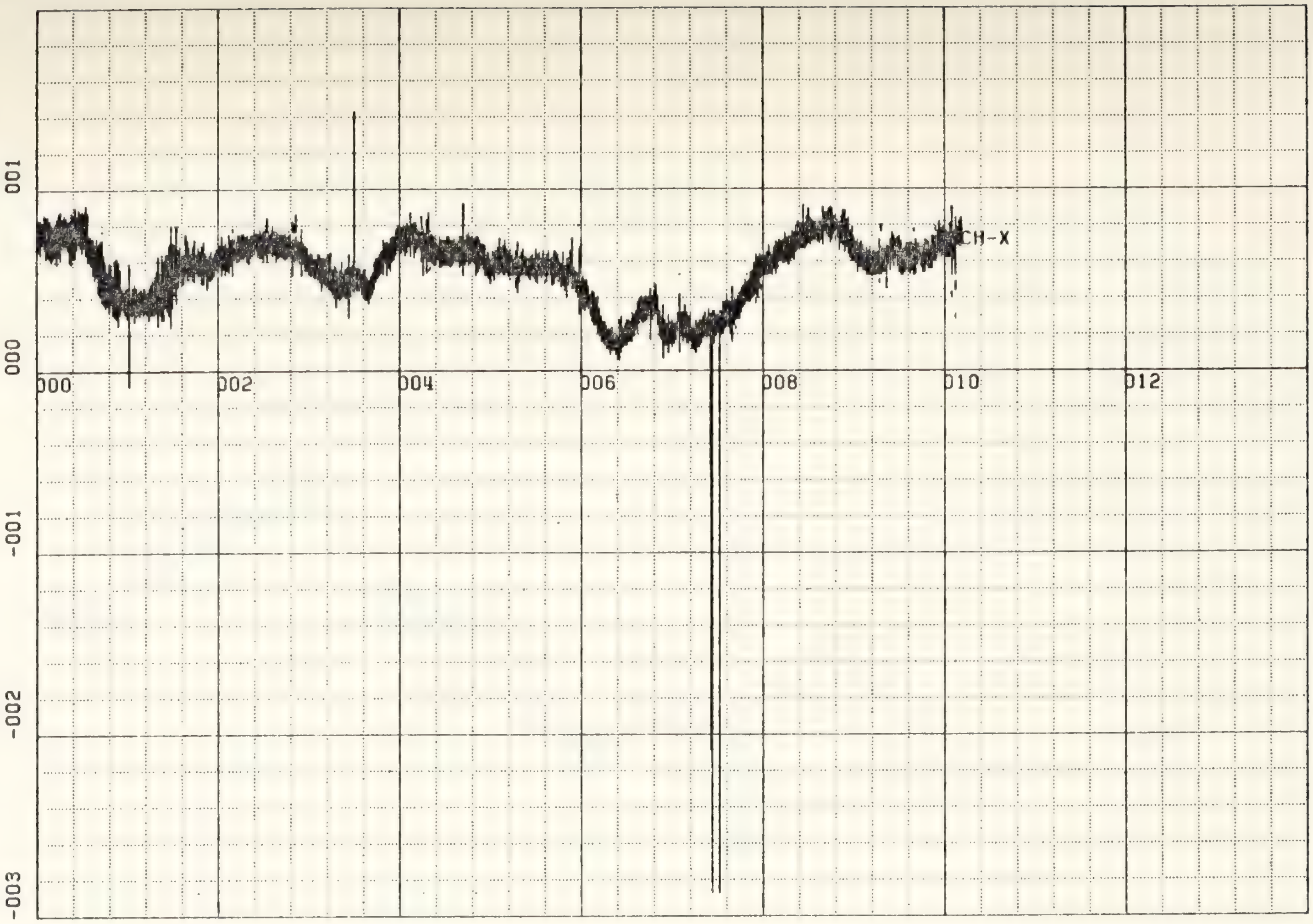

Figure 6.10 X Coil Voltage

Chew's Ridge, 1545 - 1602 Local

Voltage (1 volt/inch) vs Time (200 seconds/inch).

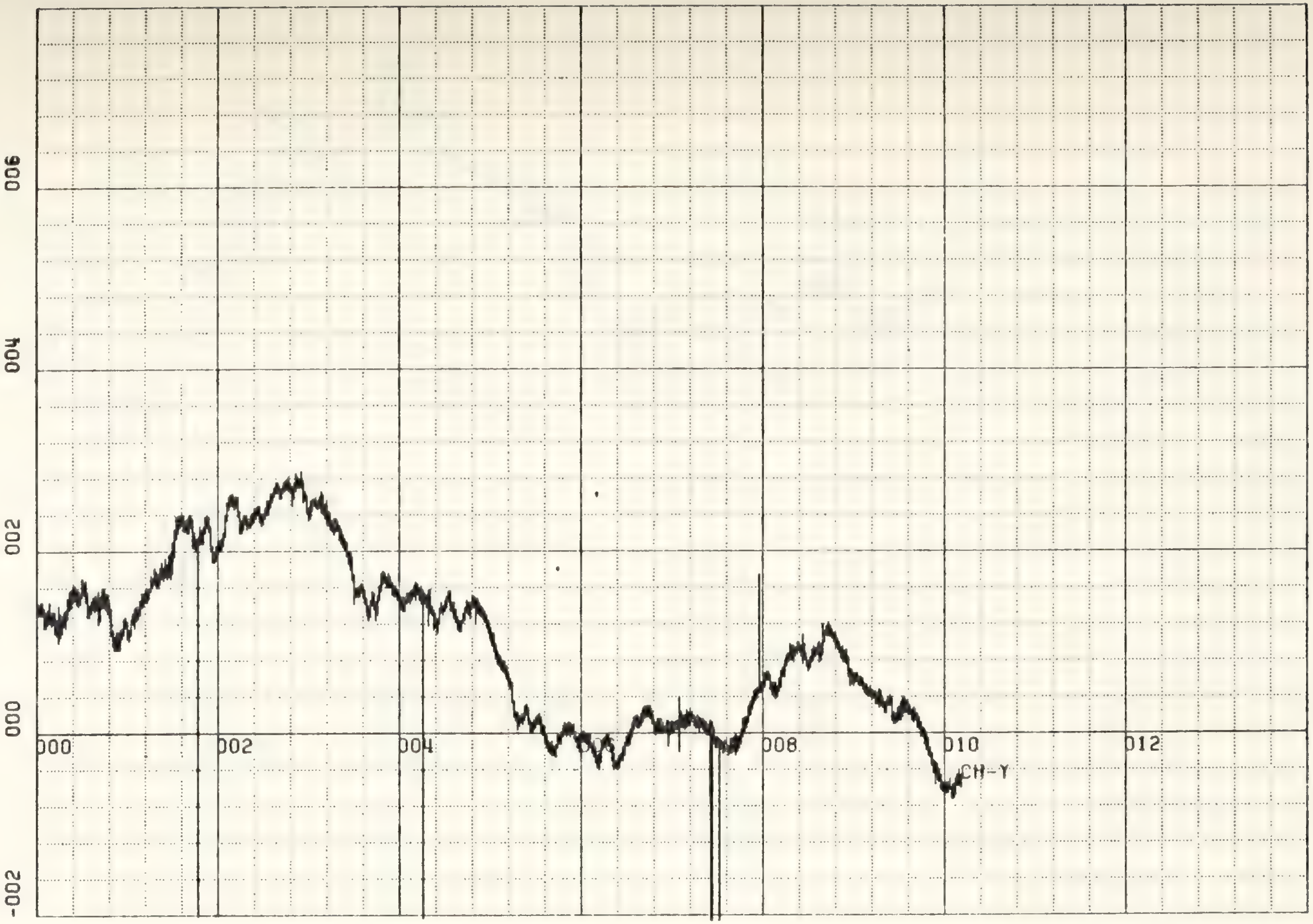

Figure 6.11 Y Coil Voltage

Chew's Ridge, 1545 - 1602 Local

Voltage (2 volts/inch) vs Time (200 seconds/inch).

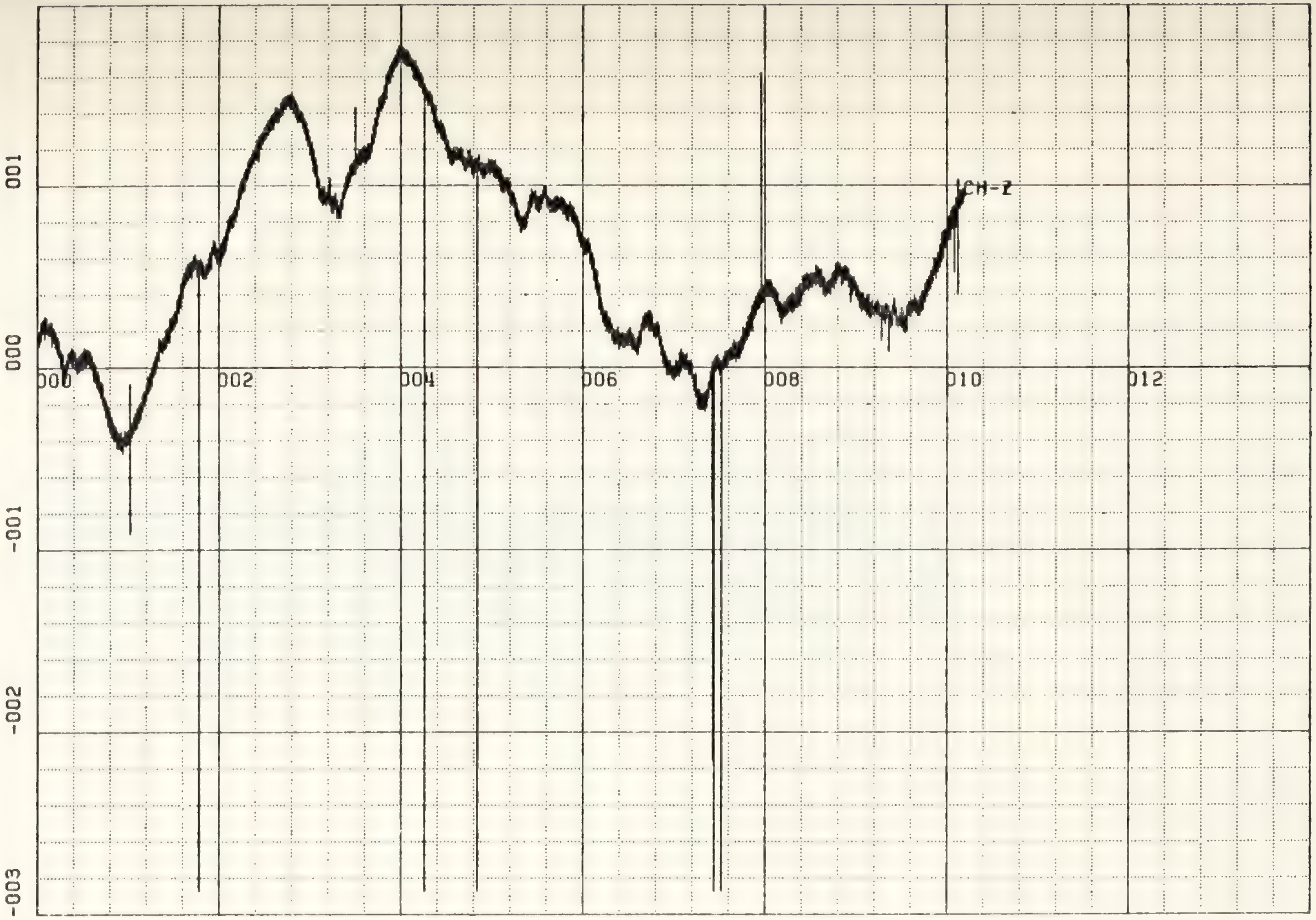

Figure 6.12 Z Coil Voltage

Chew's Ridge, 1545 - 1602 Local

Voltage (1 volt/inch) vs Time (200 seconds/inch).

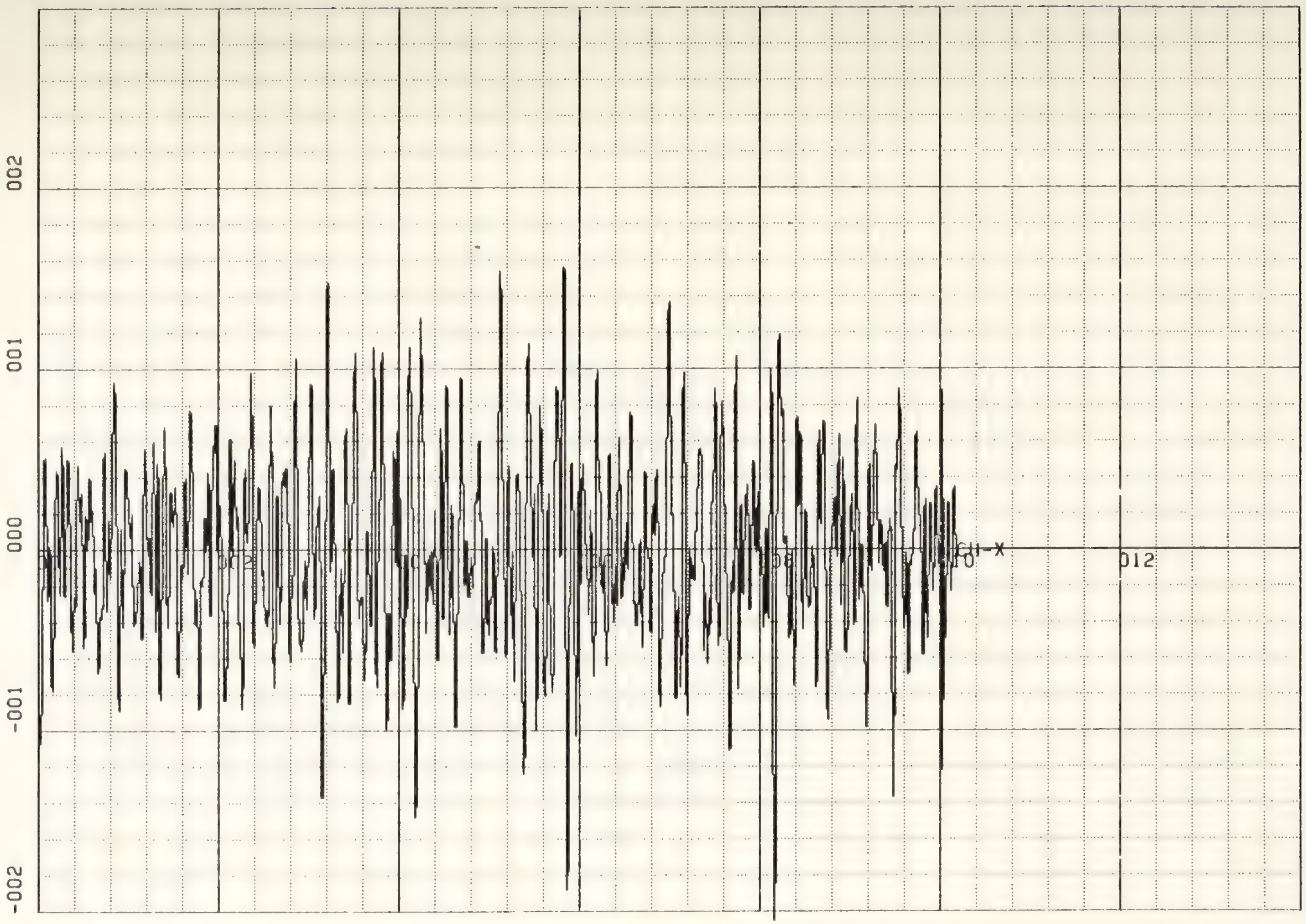

Figure 6.13 X Coil Voltage

La Mesa Village, 1610 - 1627 Local

Voltage (0.02 volts/inch) vs Time (200 seconds/inch).

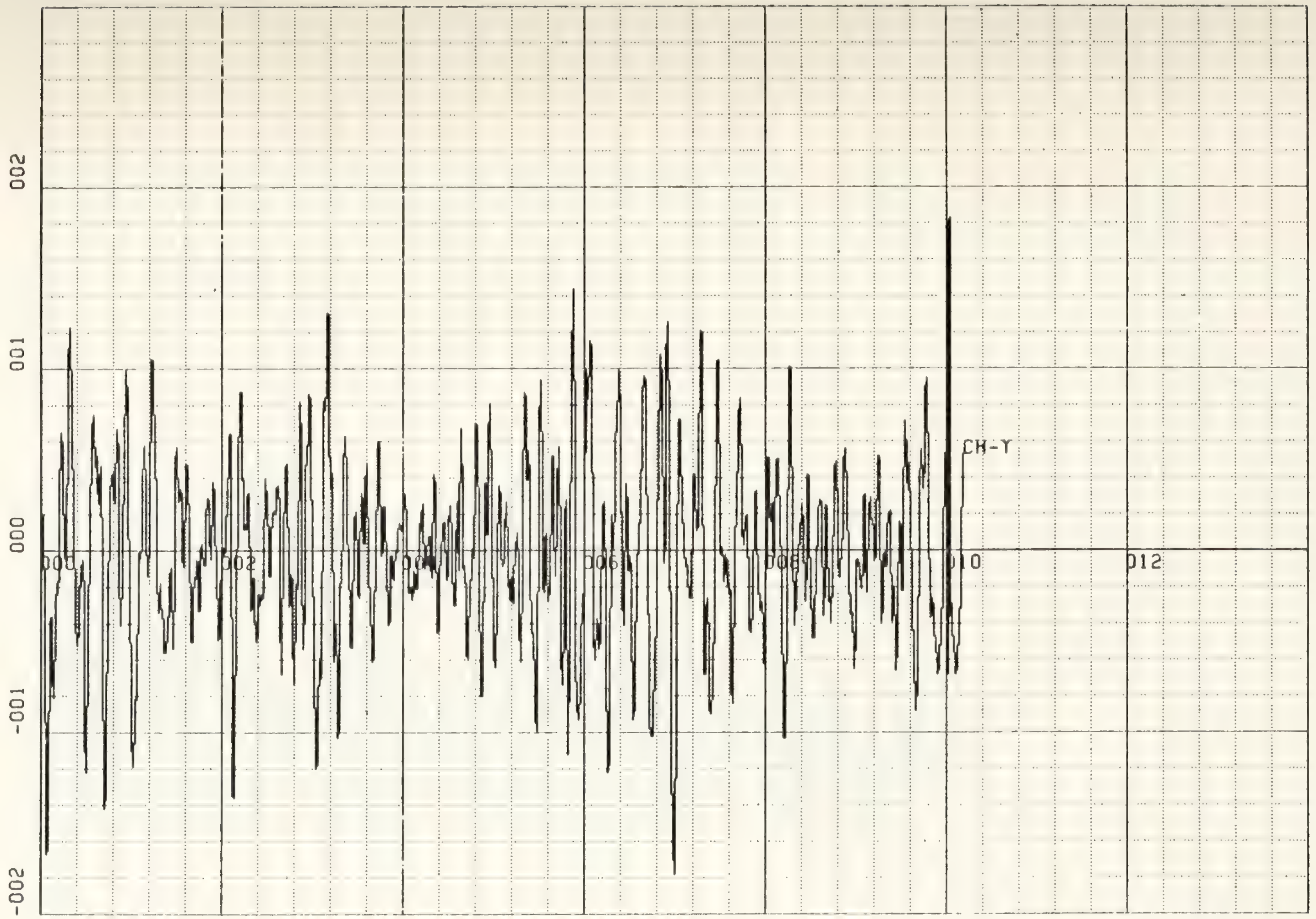

Figure 6.14 Y Coil Voltage

La Mesa Village, 1610 - 1627 Local

Voltage (0.01 volts/inch) vs Time (200 seconds/inch).

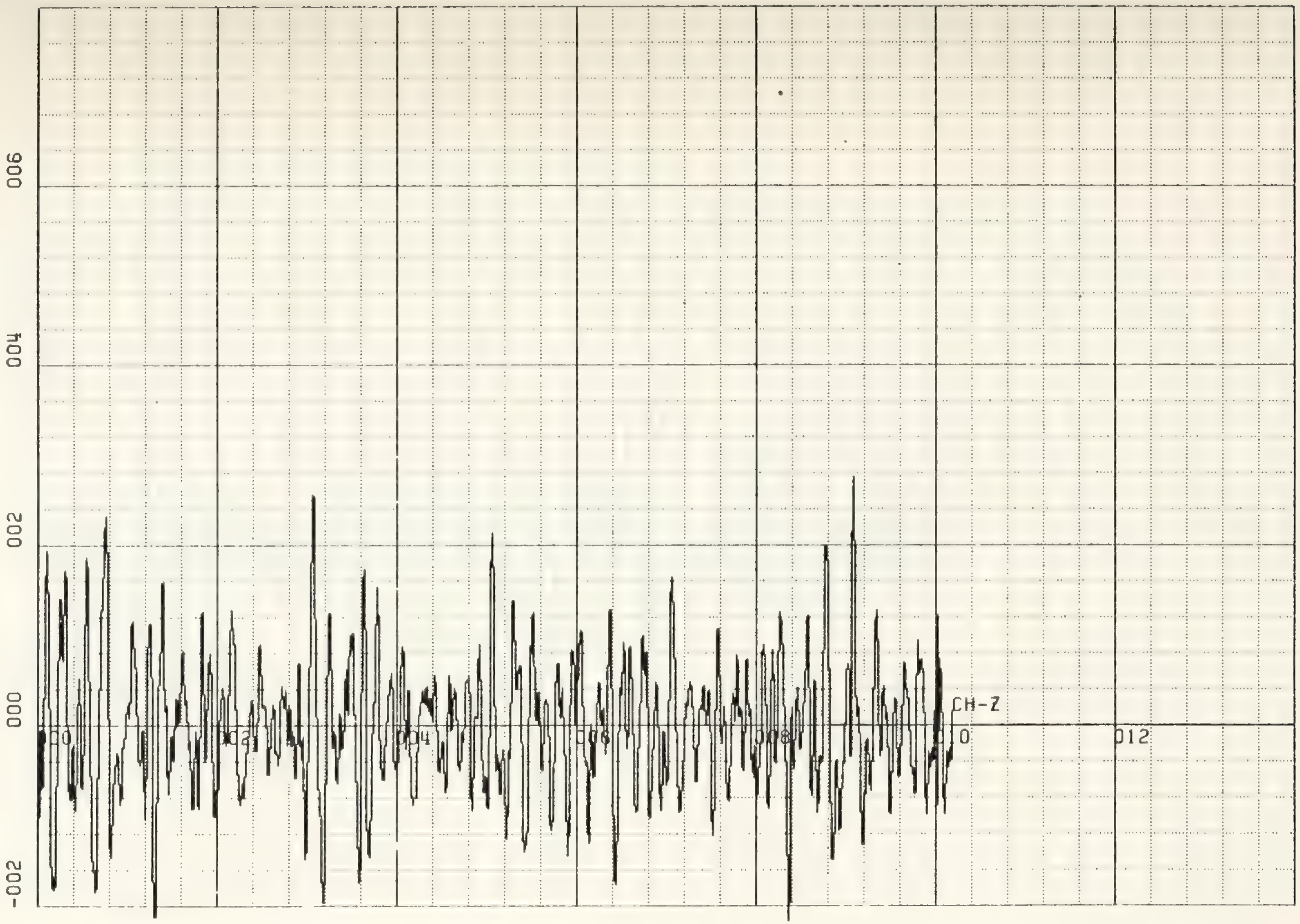

Figure 6.15 Z Coil Voltage

La Mesa Village, 1610 - 1627 Local

Voltage (0.02 volts/inch) vs Time (200 seconds/inch).

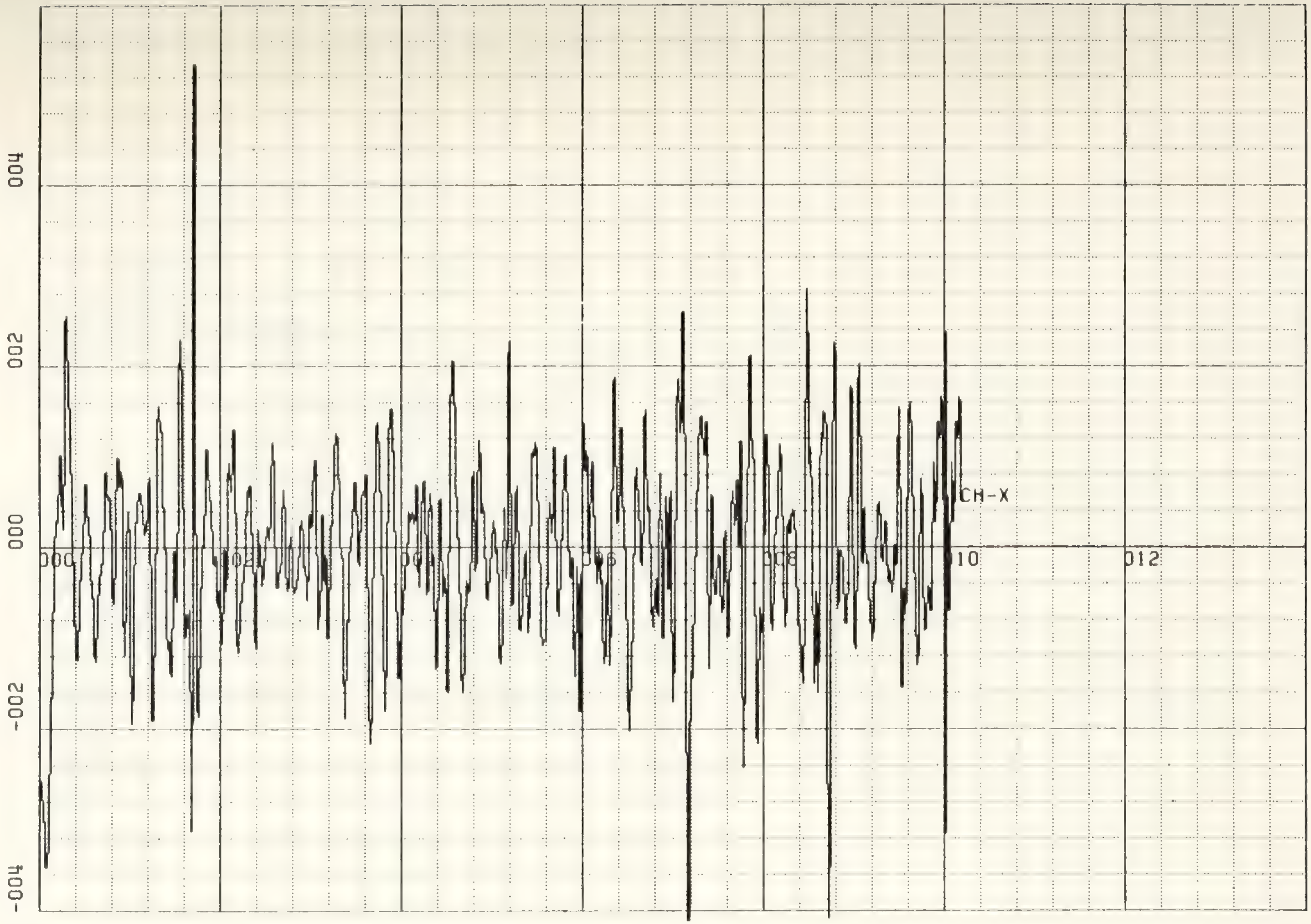

Figure 6.16 X Coil Voltage

Chew's Ridge, 1610 - 1627 Local

Voltage (0.02 volts/inch) vs Time (200 seconds/inch).

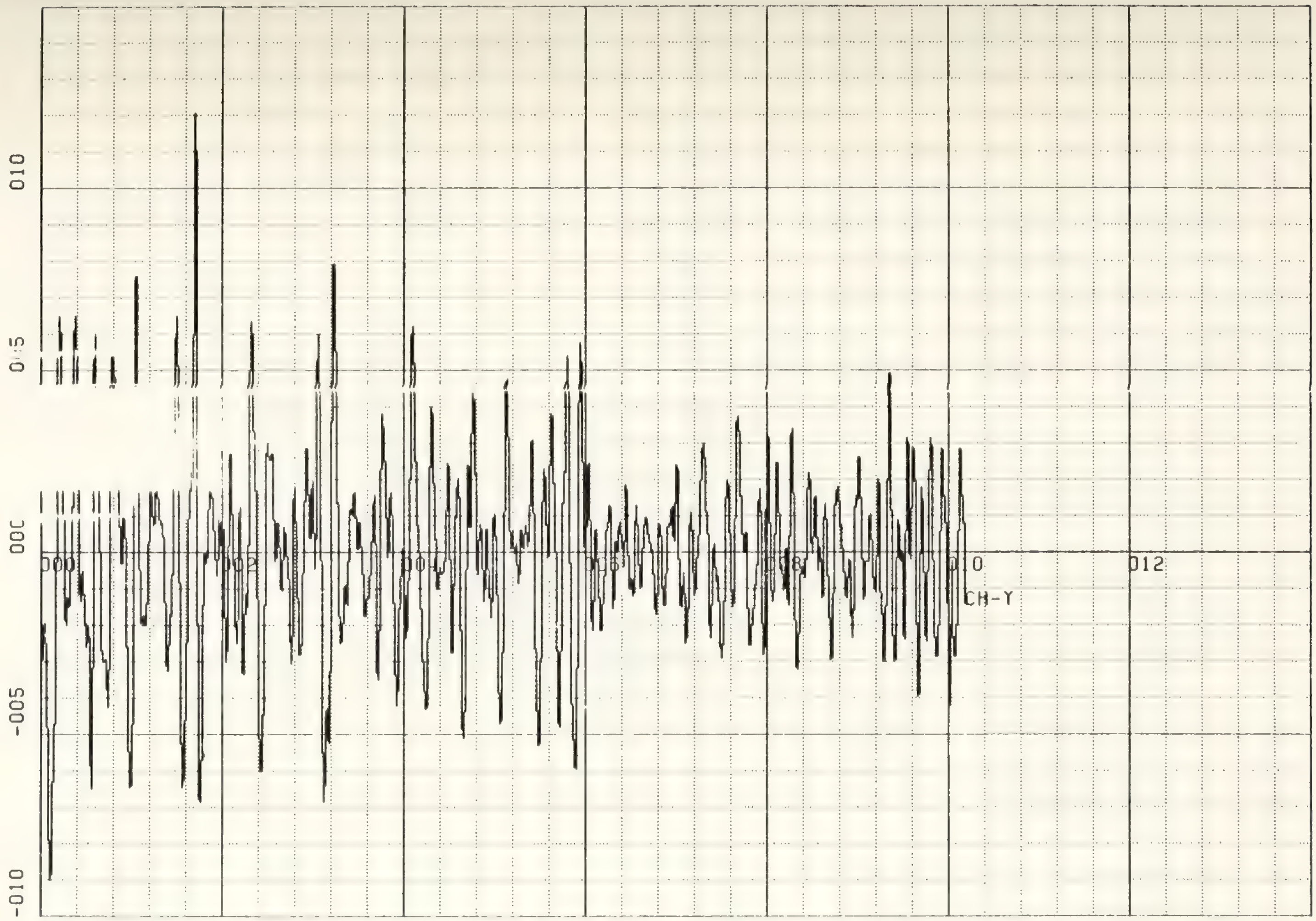

Figure 6.17 Y Coil Voltage

Chew's Ridge, 1610 - 1617 Local

Voltage (0.05 volts/inch) vs Time (200 seconds/inch).

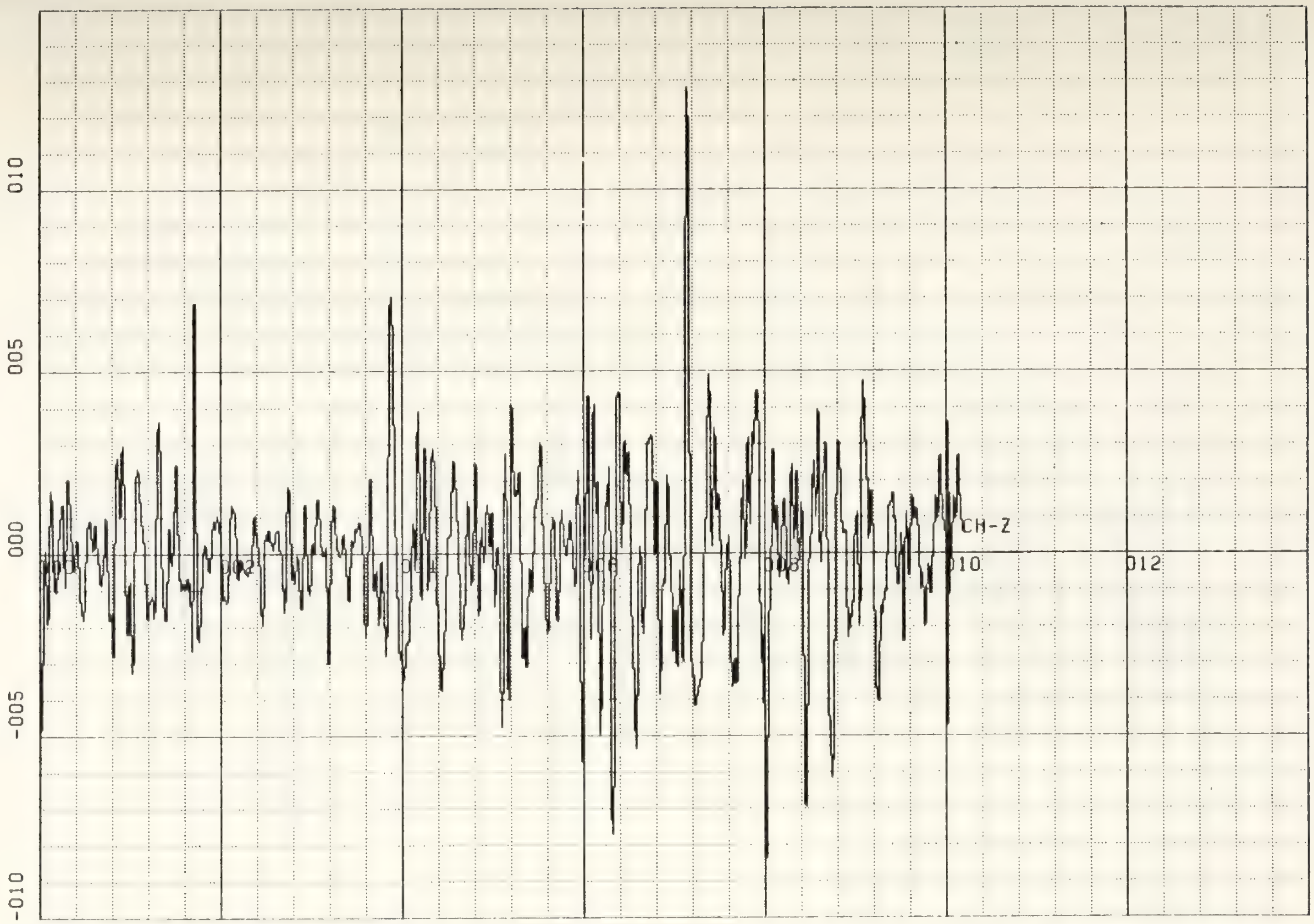

Figure 6.18 Z Coil Voltage

Chew's Ridge, 1610 - 1627 Local

Voltage (0.05 volts/inch) vs Time (200 seconds/inch).

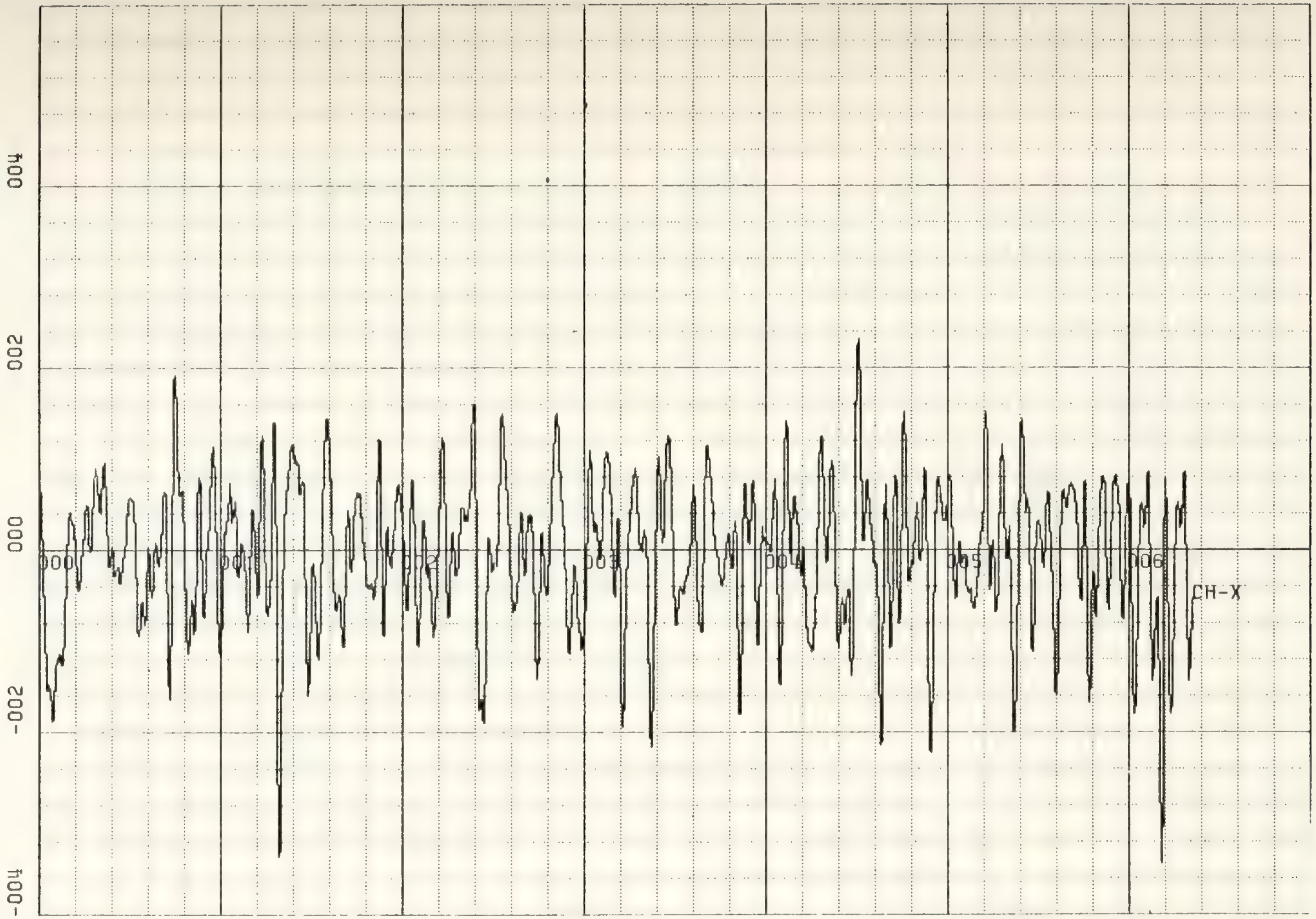

Figure 6.19 X Coil Voltage

La Mesa Village, 1802 - 1812 Local

Voltage (0.02 volts/inch) vs Time (100 seconds/inch).

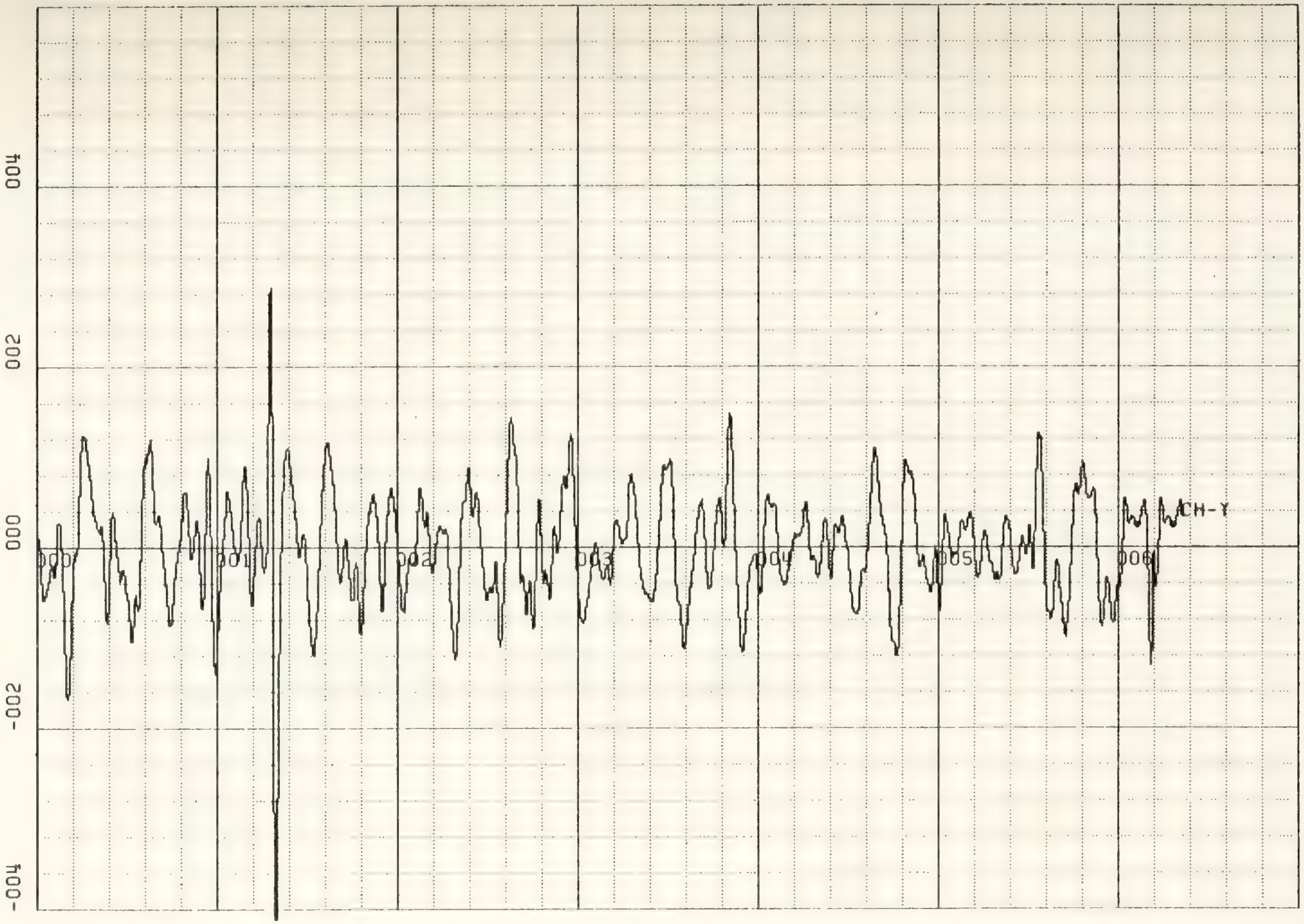

Figure 6.20 Y Coil Voltage

La Mesa Village, 1802 - 1812 Local

Voltage (0.02 volts/inch) vs Time (100 seconds/inch).

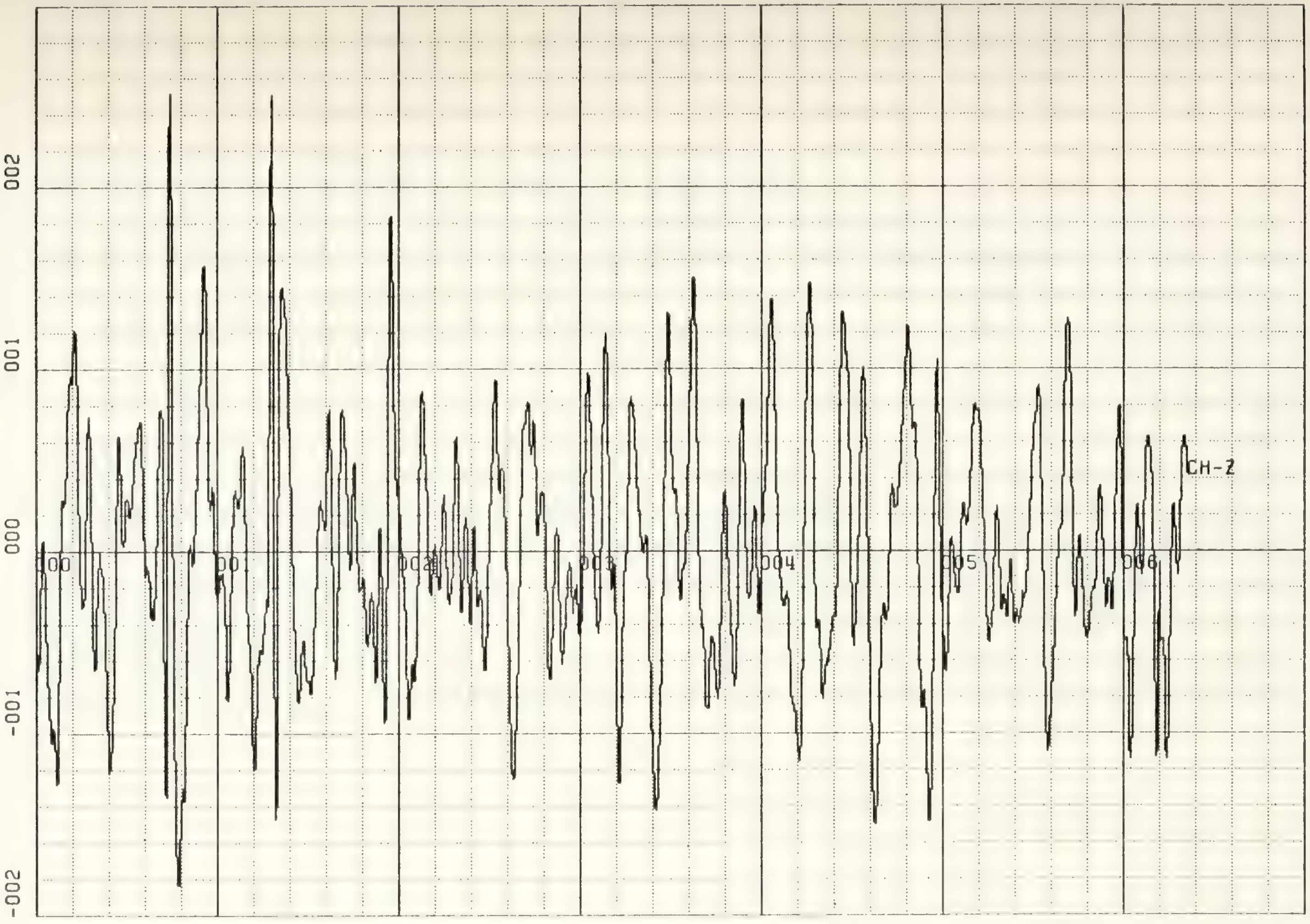

Figure 6.21 Z Coil Voltage

La Mesa Village, 1802 - 1812 Local

Voltage (0.01 volts/inch) vs Time (100 seconds/inch).

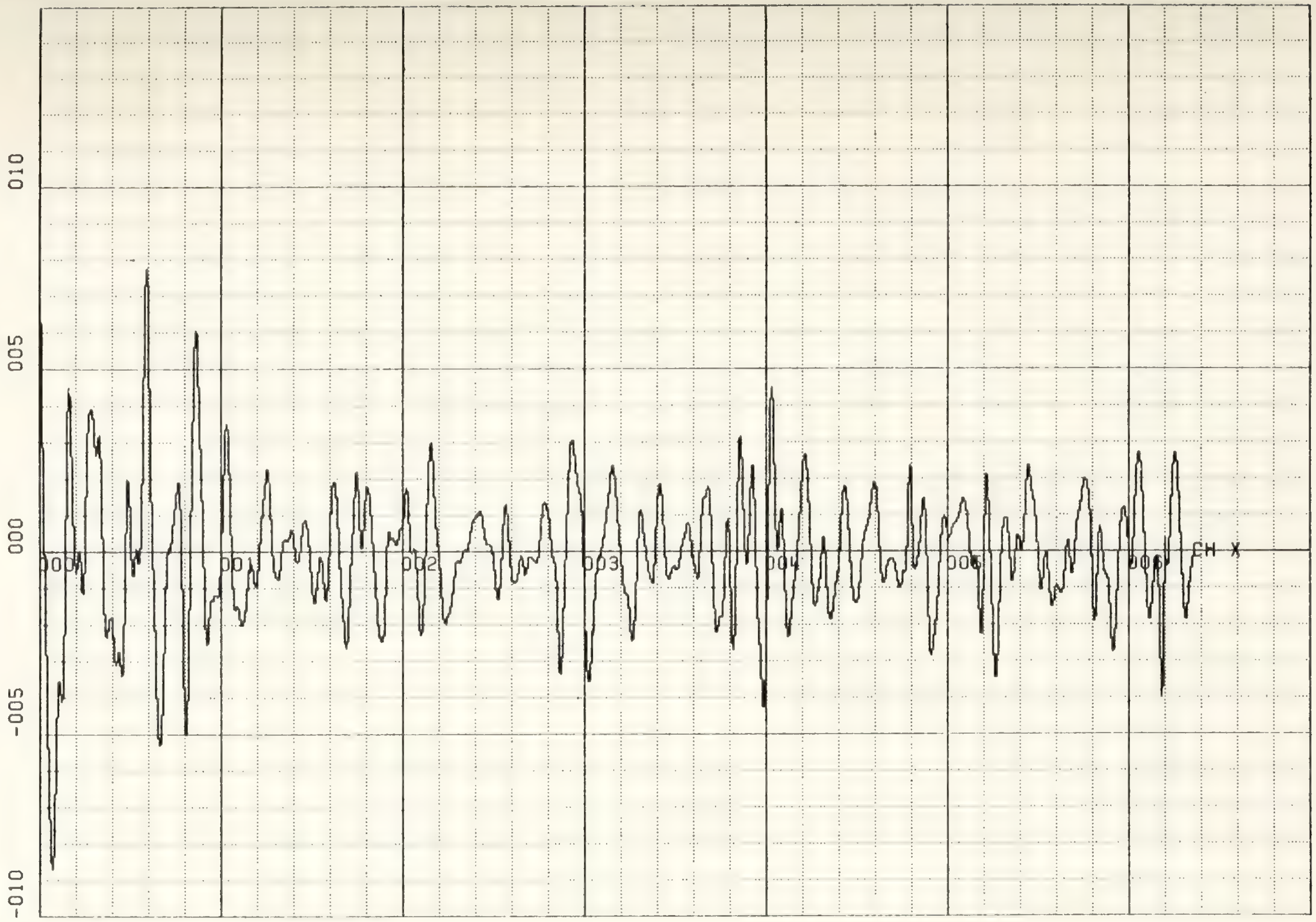

Figure 6.22 X Coil Voltage

Chew's Ridge, 1802 - 1812 Local

Voltage (0.05 volts/inch) vs Time (100 seconds/inch).

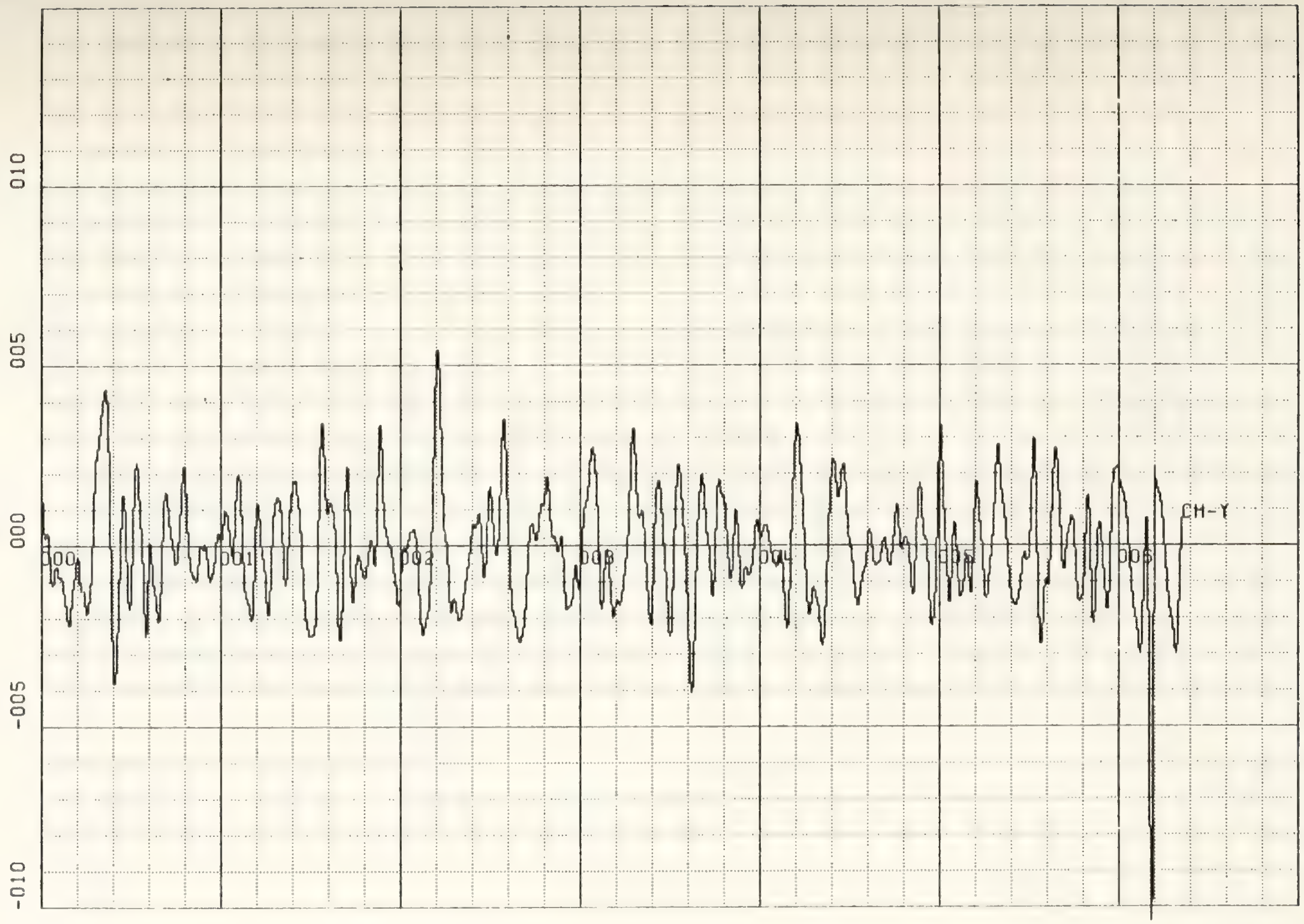

Figure 6.23 Y Coil Voltage

Chew's Ridge, 1802 - 1812 Local

Voltage (0.05 volts/inch) vs Time (100 seconds/inch).

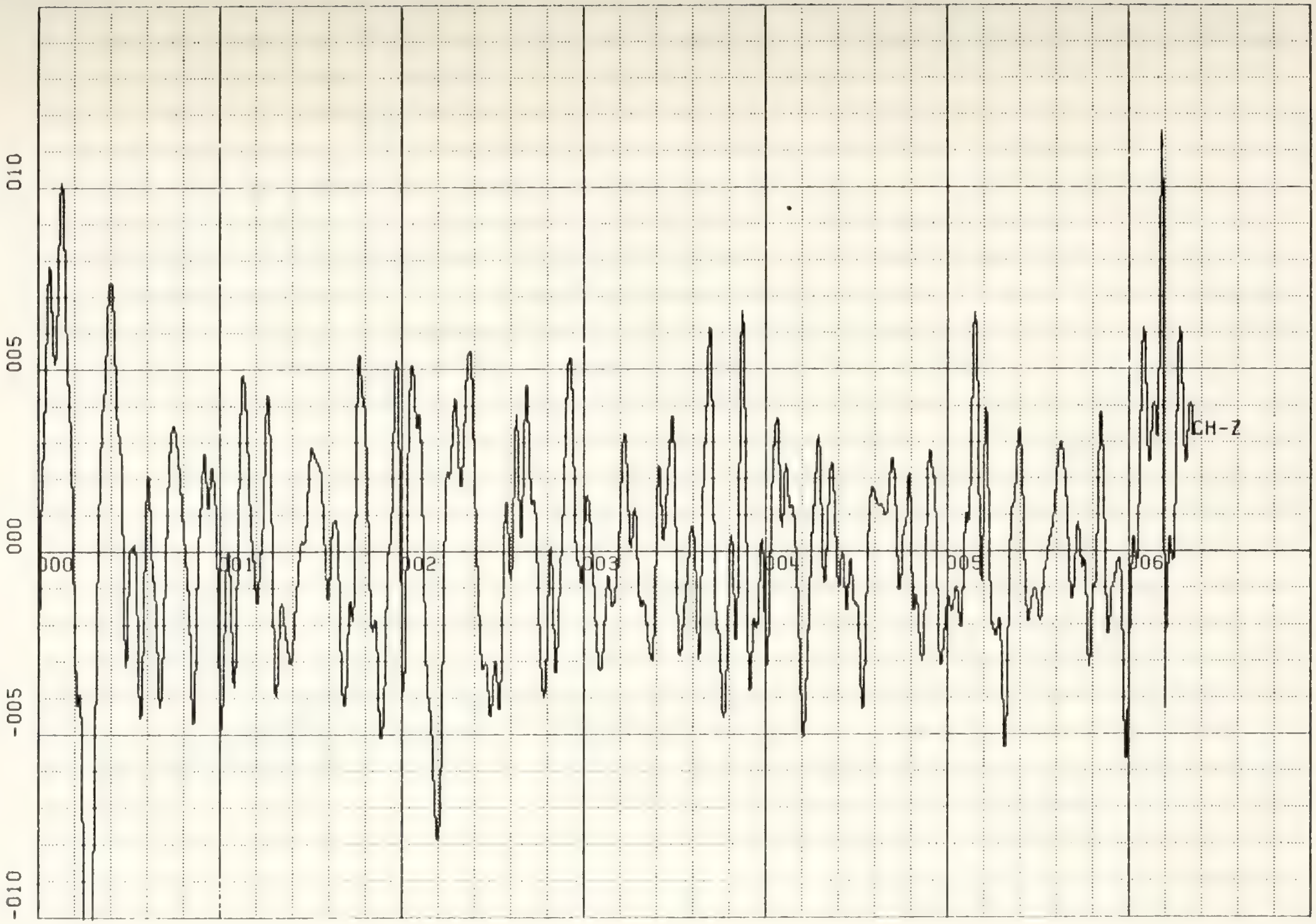

Figure 6.24 Z Coil Voltage

Chew's Ridge, 1802 - 1812 Local

Voltage (0.05 volts/inch) vs Time (100 seconds/inch).

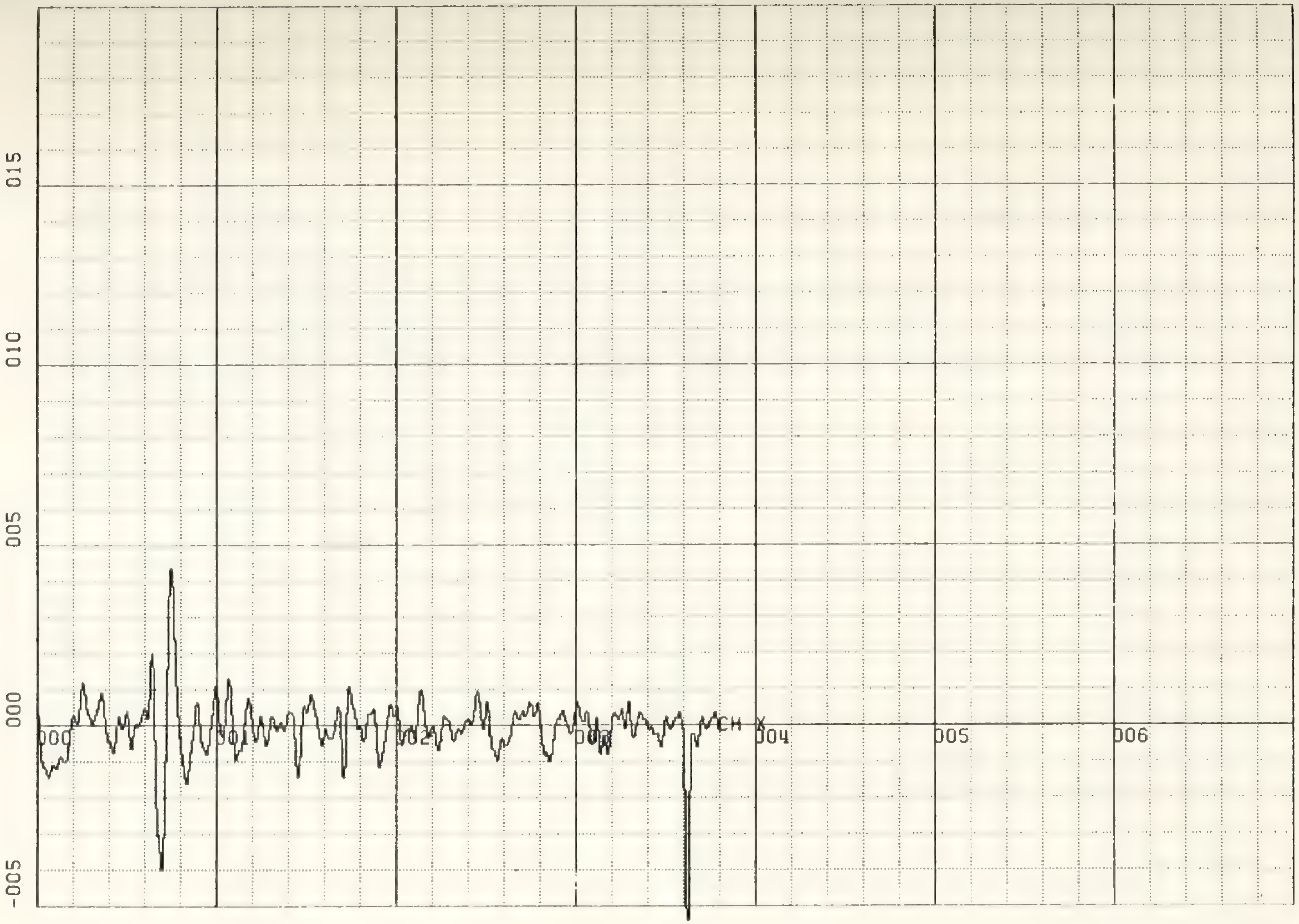

Figure 6.25 X Coil Voltage

La Mesa Village, 1834 - 1840 Local

Voltage (0.05 volts/inch) vs Time (100 seconds/inch).

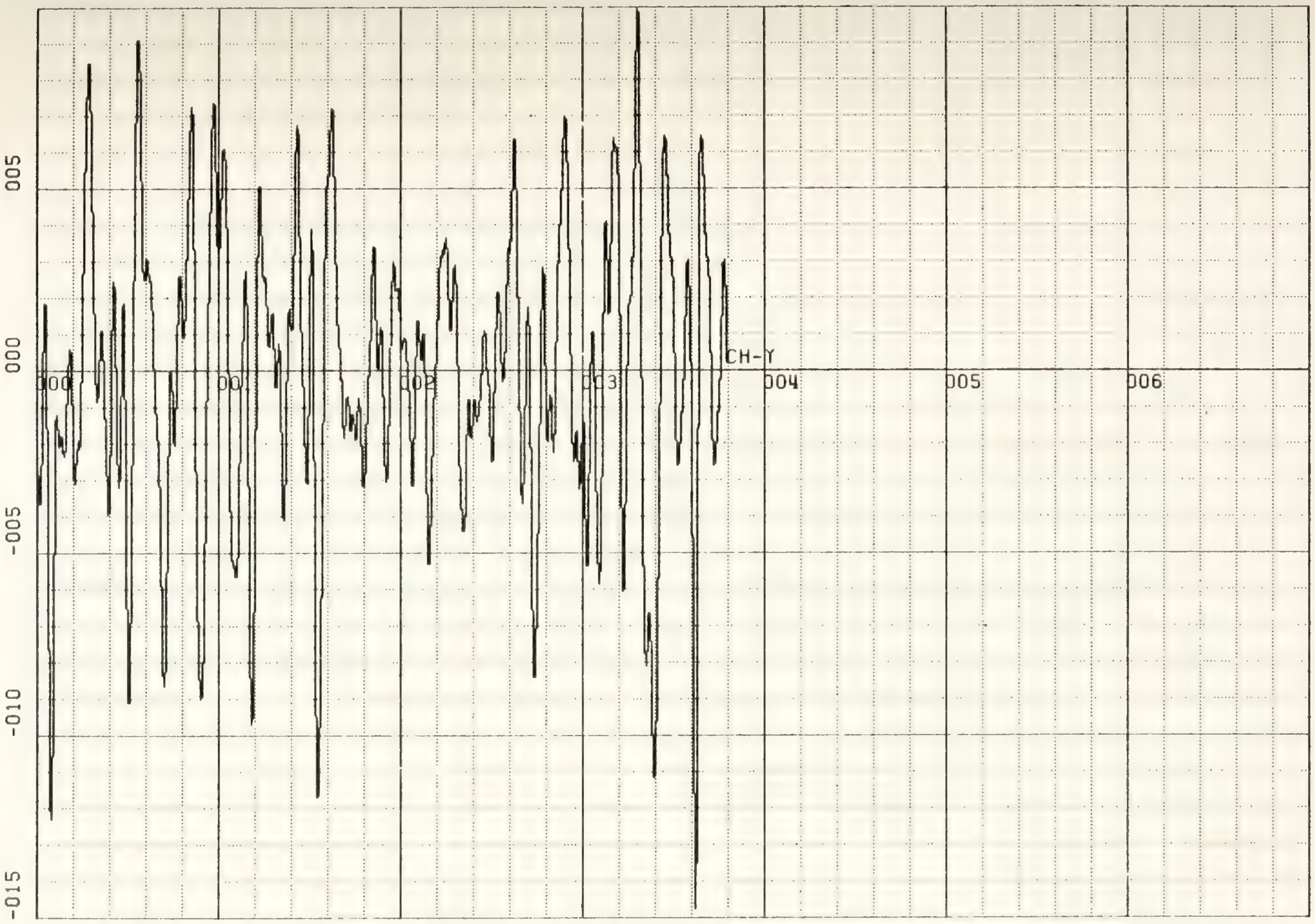

Figure 6.26 Y Coil Voltage

La Mesa Village, 1834 - 1840 Local

Voltage (0.005 volts/inch) vs Time (100 seconds/inch).

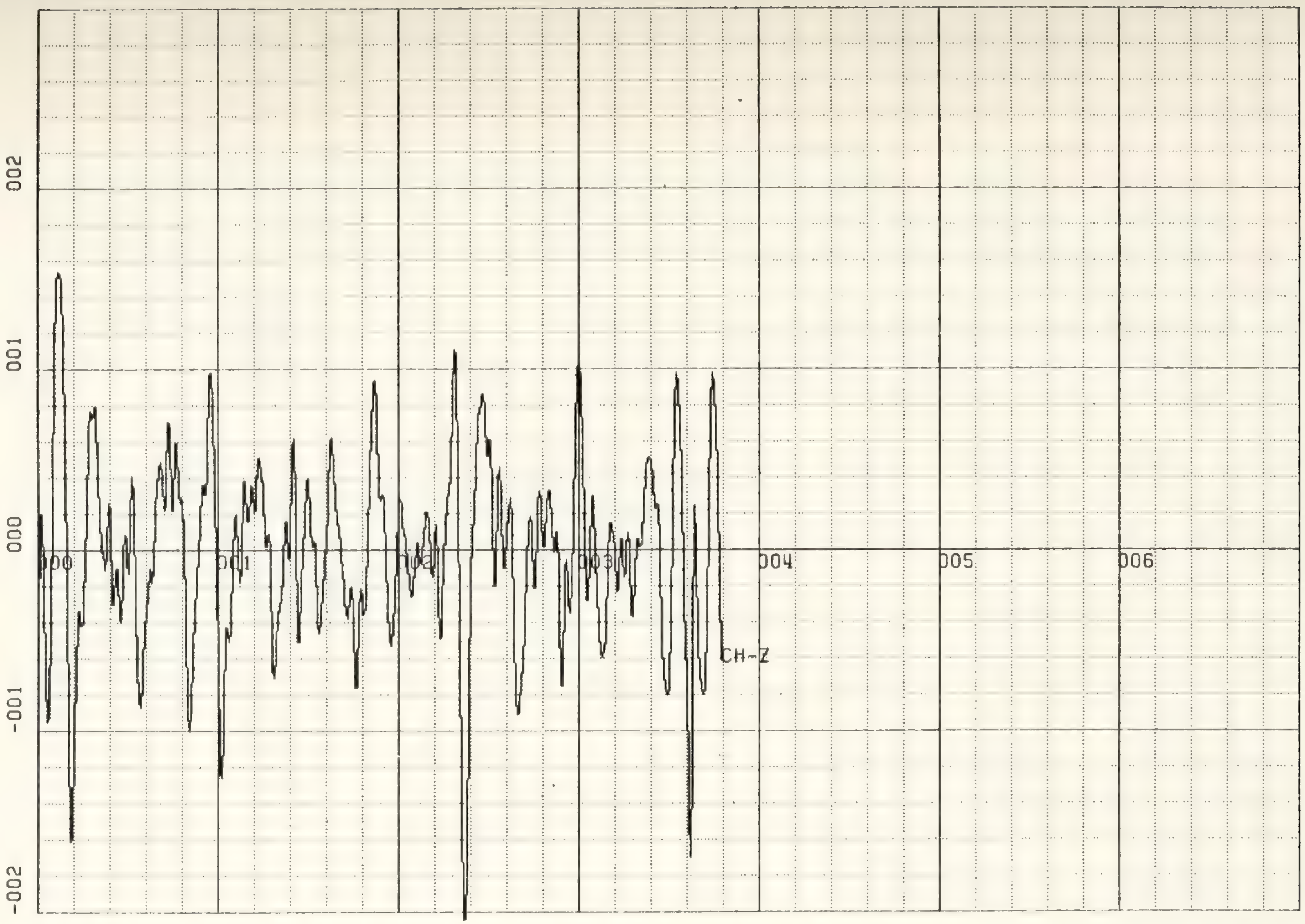

Figure 6.27 Z Coil Voltage

La Mesa Village, 1834 - 1840 Local

Voltage (0.01 volts/inch) vs Time (100 seconds/inch).

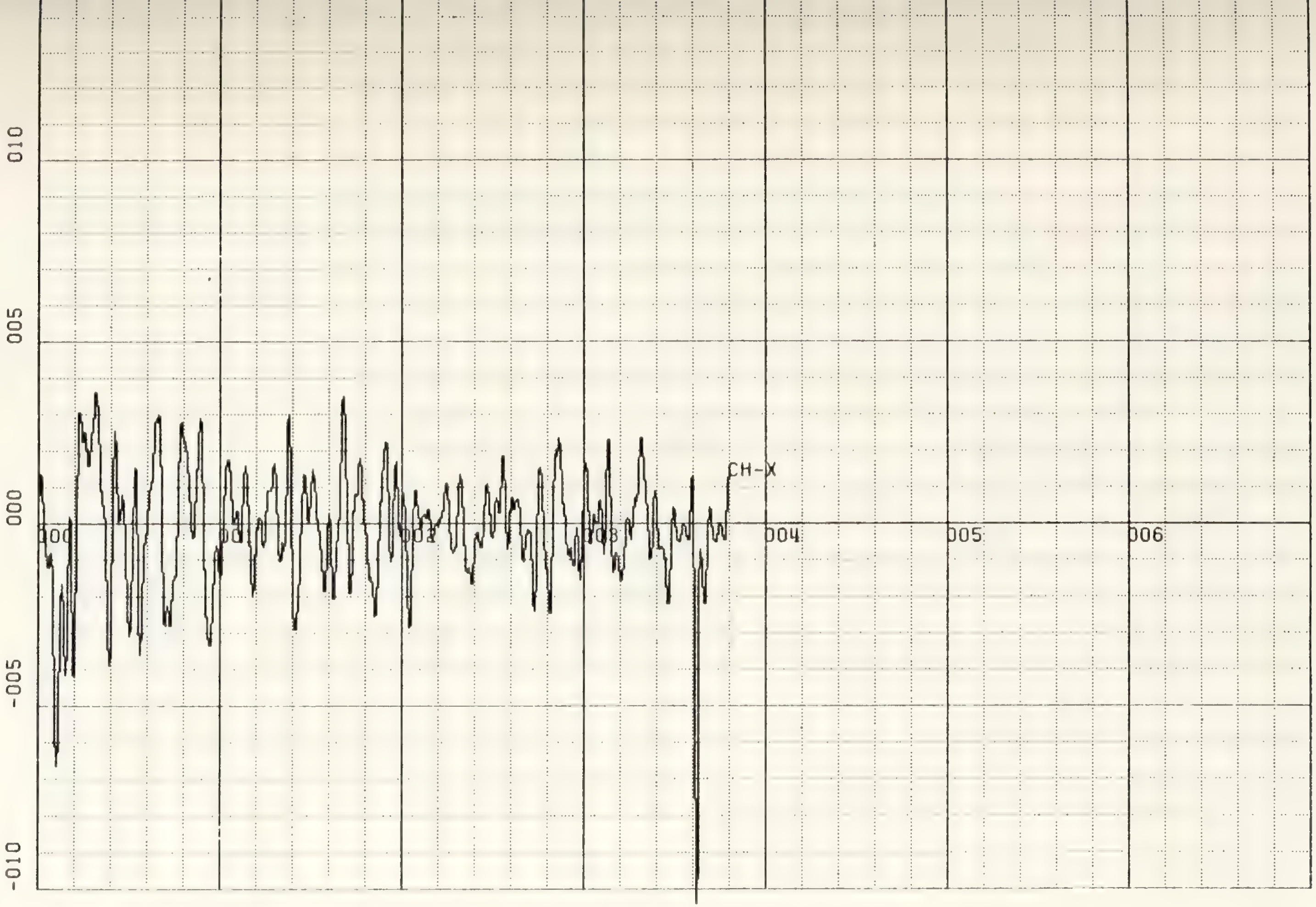

Figure 6.28 X Coil Voltage

Chew's Ridge, 1834 - 1840 Local

Voltage (0.05 volts/inch) vs Time (100 seconds/inch).

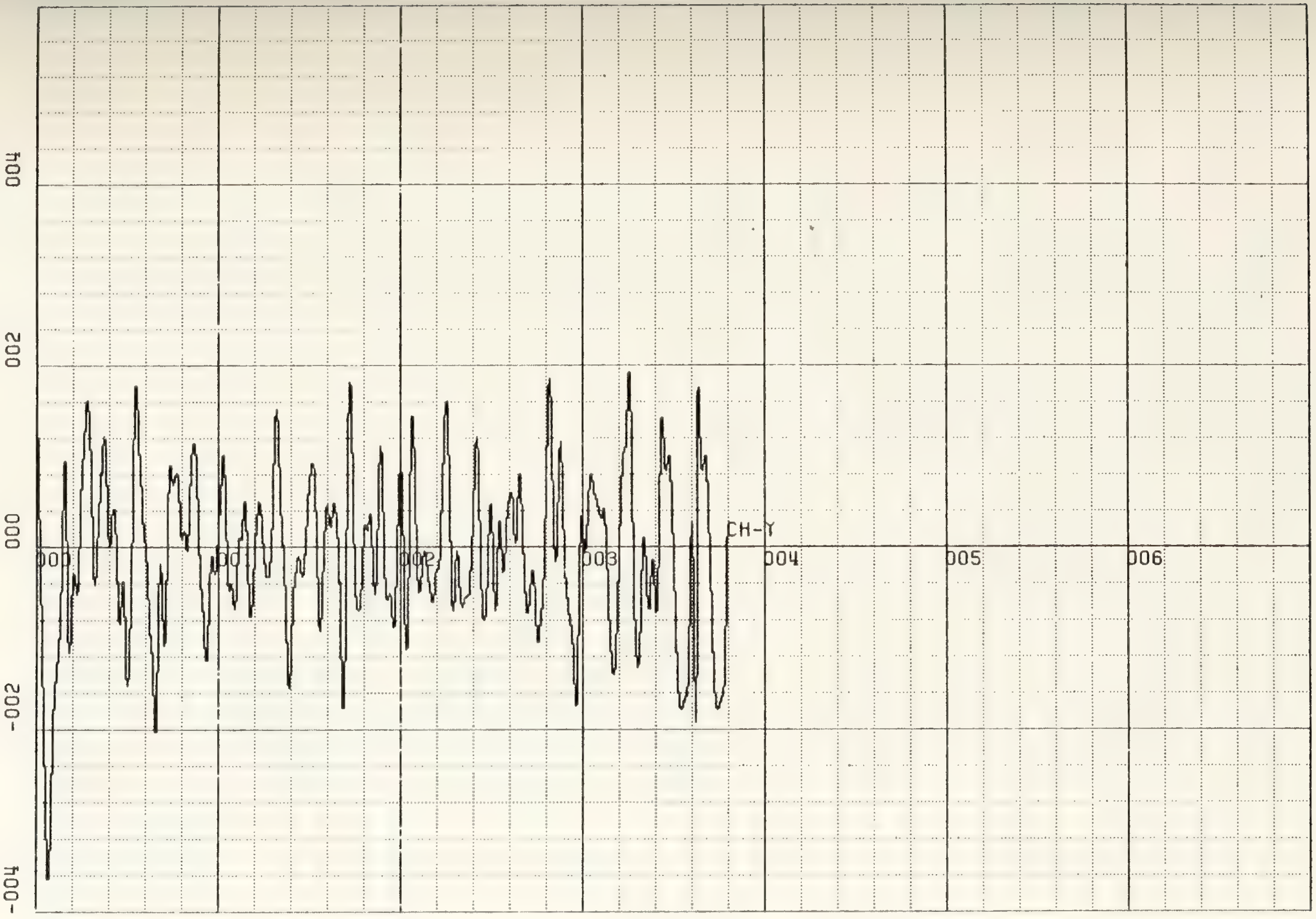

Figure 6.29 Y Coil Voltage

Chew's Ridge, 1834 - 1840 Local

Voltage (0.02 volts/inch) vs Time (100 seconds/inch).

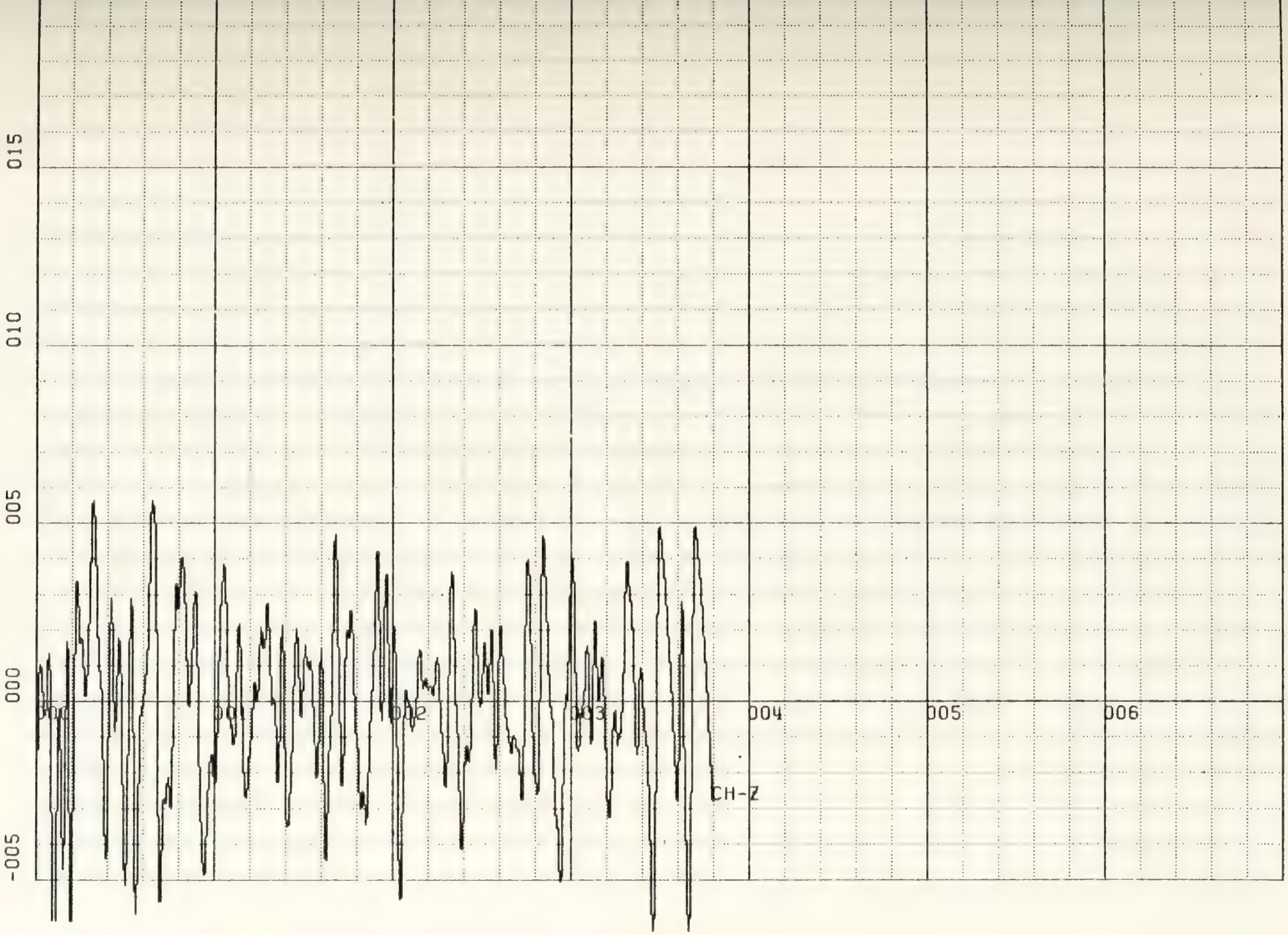

Figure 6.30 Z Coil Voltage

Chew's Ridge, 1834 - 1840 Local

Voltage (0.05 volts/inch) vs Time (100 seconds/inch).

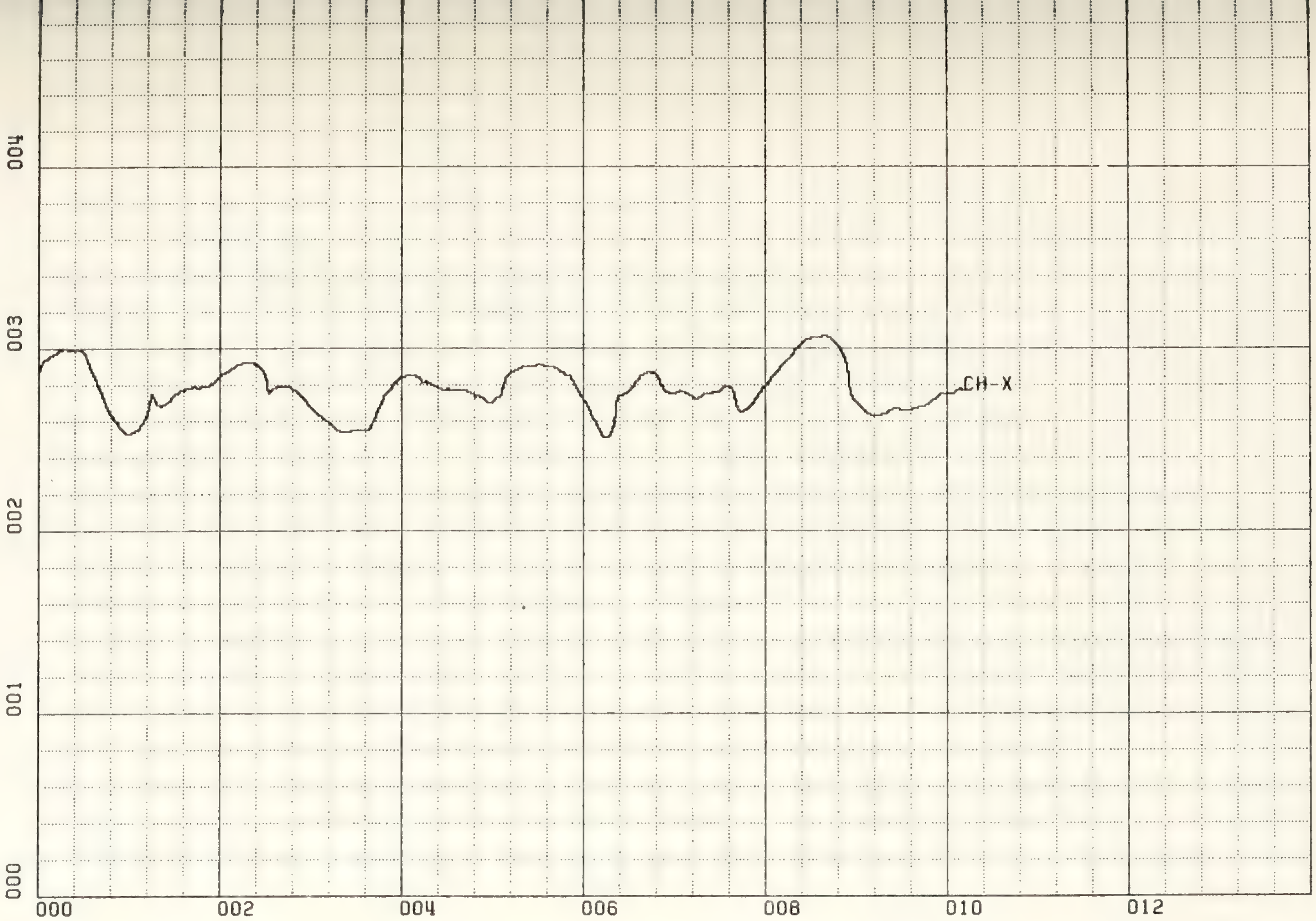

Figure 6.31 X Coil Magnetic Field

Chew's Ridge, 1545 - 1602 Local

Field (10 nanoteslas/inch) vs Time (200 seconds/inch).

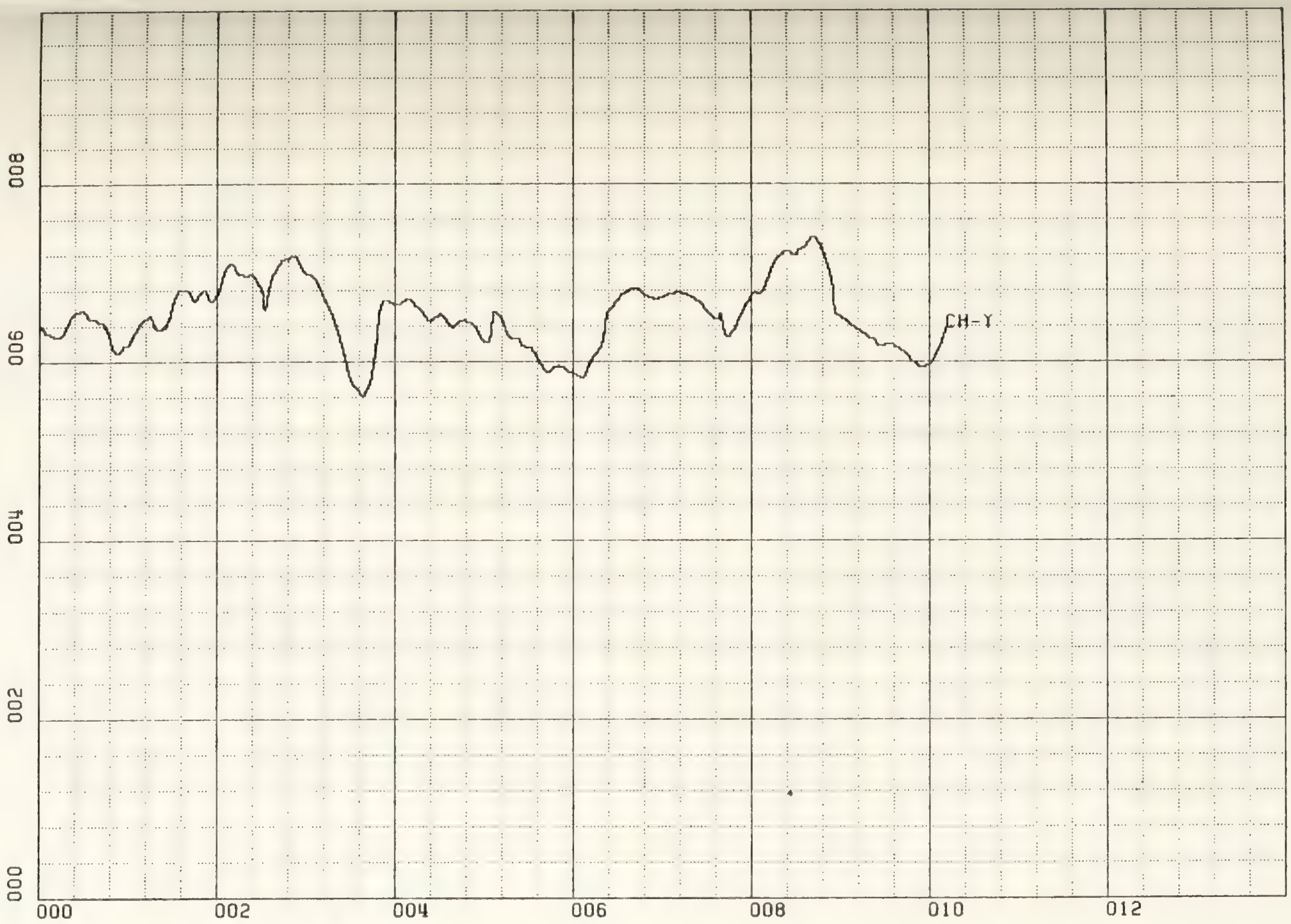

Figure 6.32 Y Coil Magnetic Field
Chew's Ridge, 1545 - 1602 Local
Field (20 nanoteslas/inch) vs Time (200 seconds/inch).

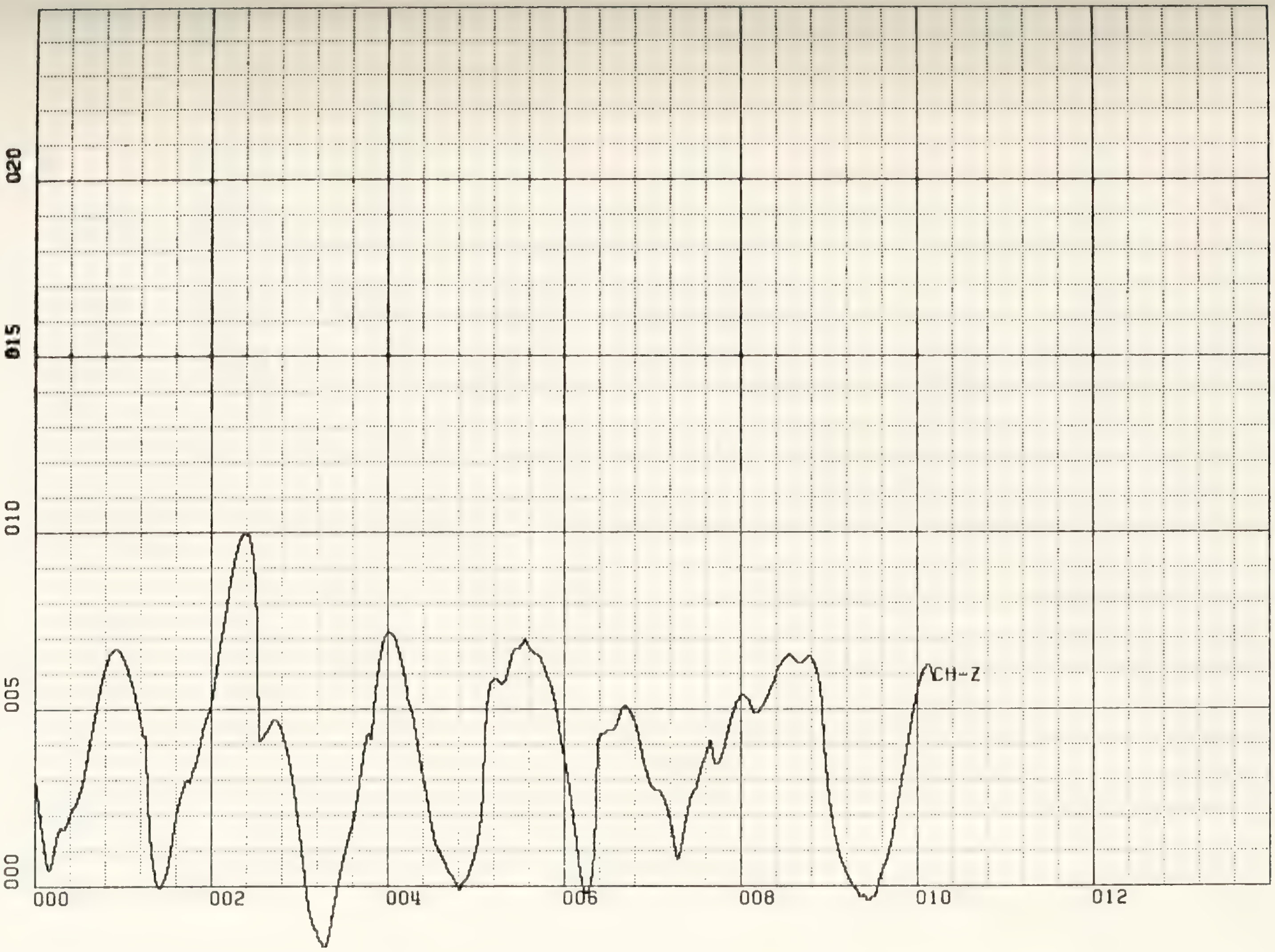

Figure 6.33 X Coil Magnetic Field

Chew's Ridge, 1545 - 1602 Local

Field (5 nanoteslas/inch) vs Time (200 seconds/inch).

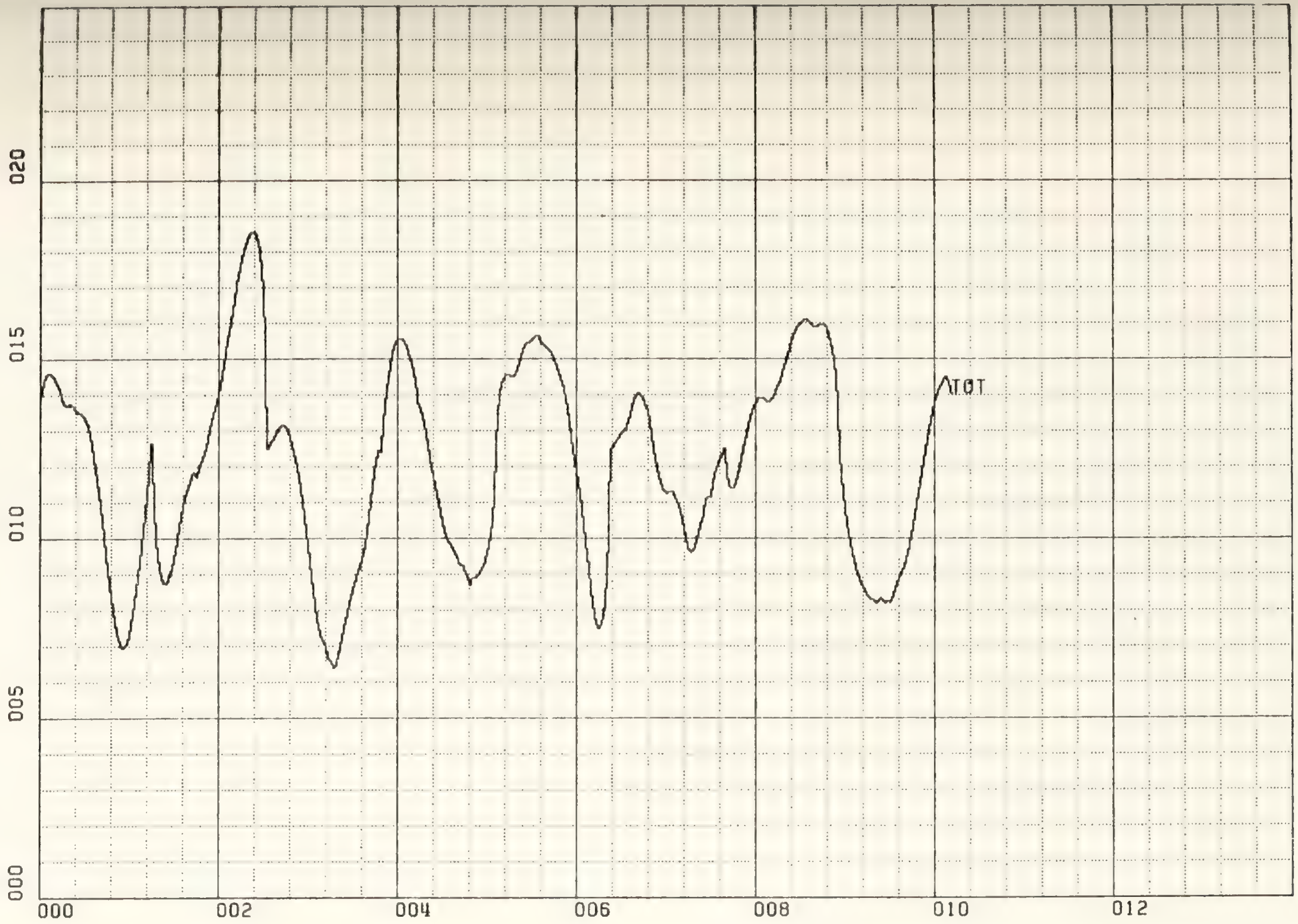

Figure 6.34 Total Magnetic Field

Chew's Ridge, 1545 - 1602 Local

Field (5 nanoteslas/inch) vs Time (200 seconds/inch).

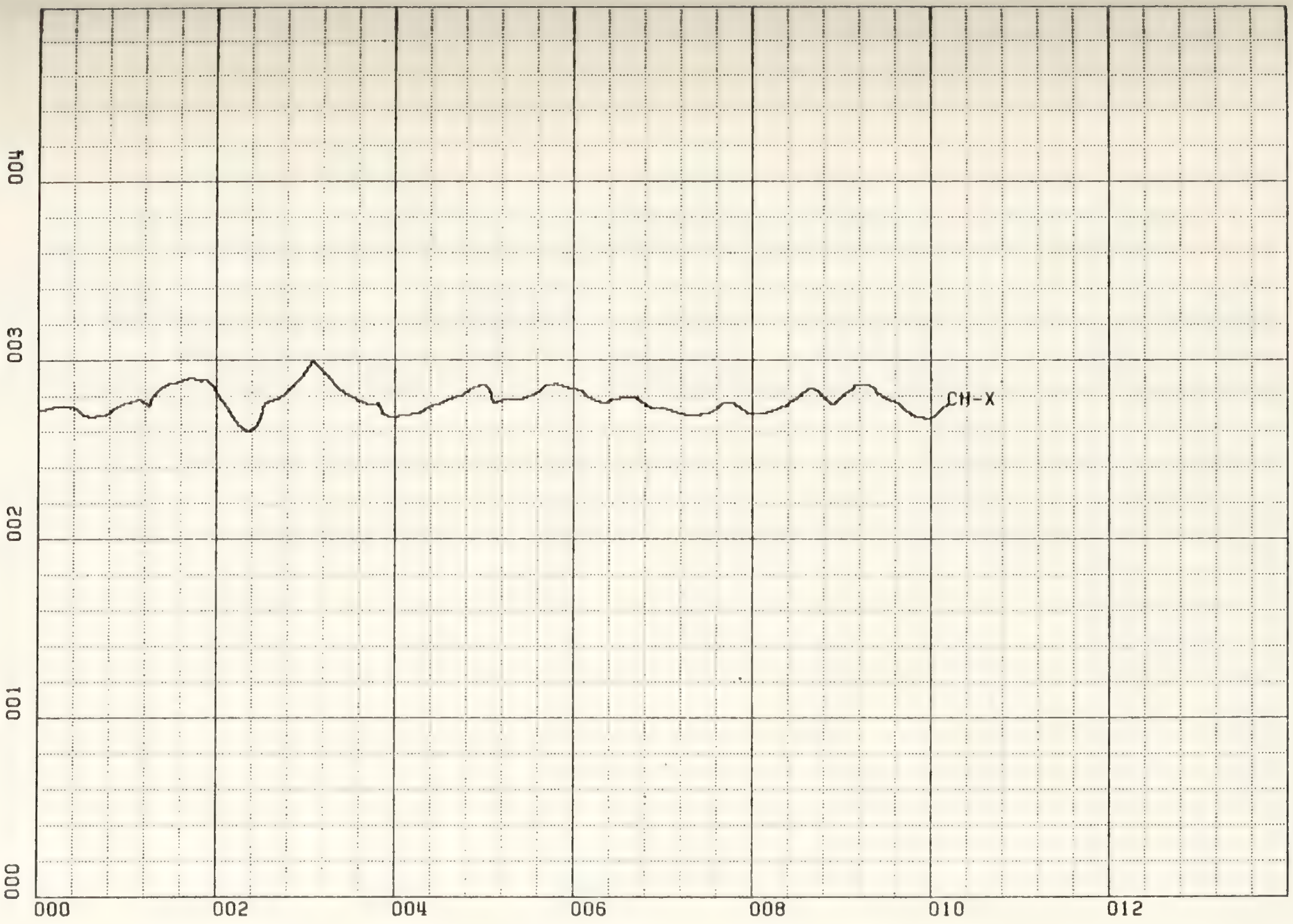

Figure 6.35 X Coil Magnetic Field

Chew's Ridge, 1310 - 1317 Local

Field (10 nanoteslas/inch) vs Time (200 seconds/inch).

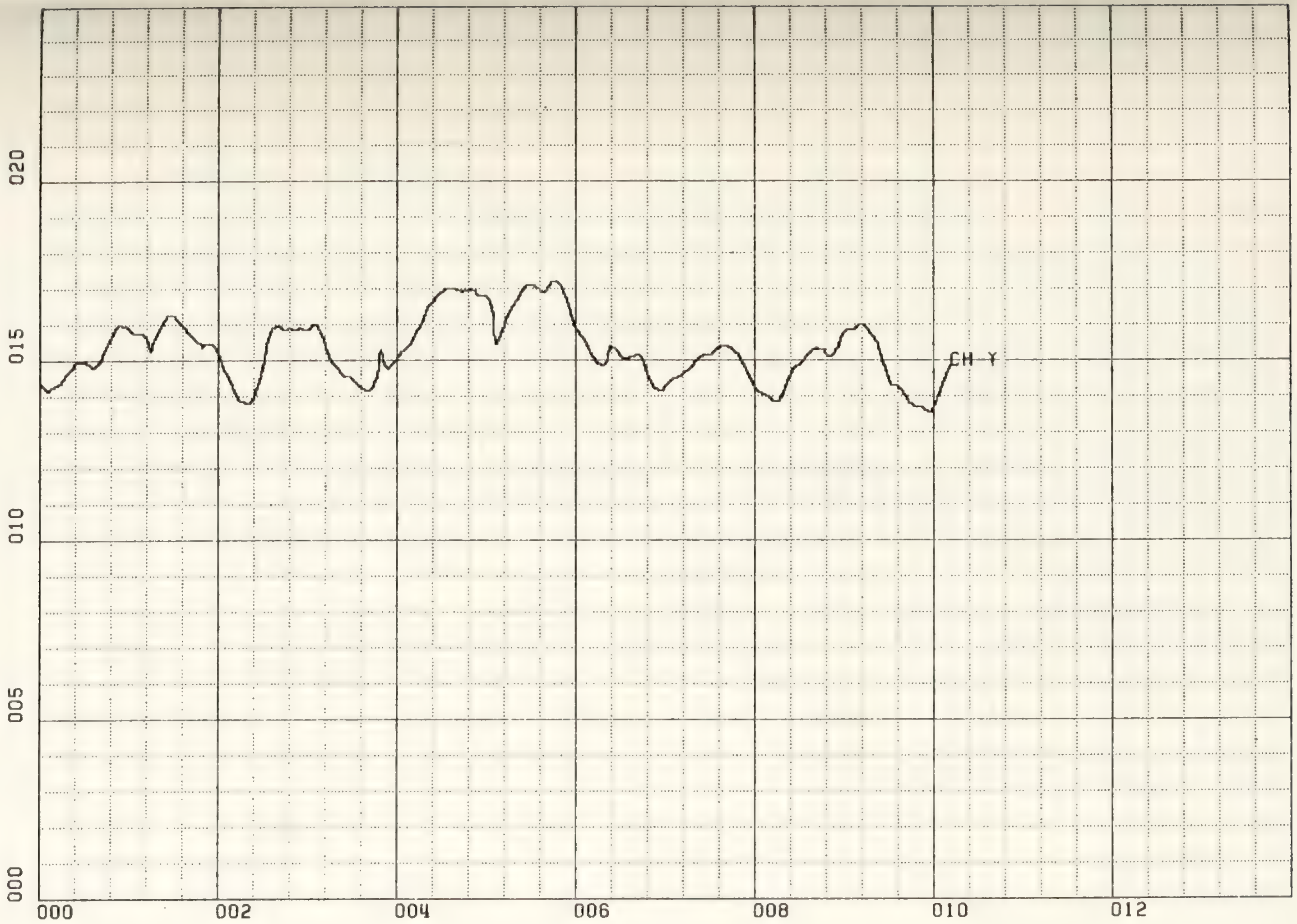

Figure 6.36 Y Coil Magnetic Field

Chew's Ridge, 1310 - 1317 Local

Field (5 nanoteslas/inch) vs Time (200 seconds/inch).

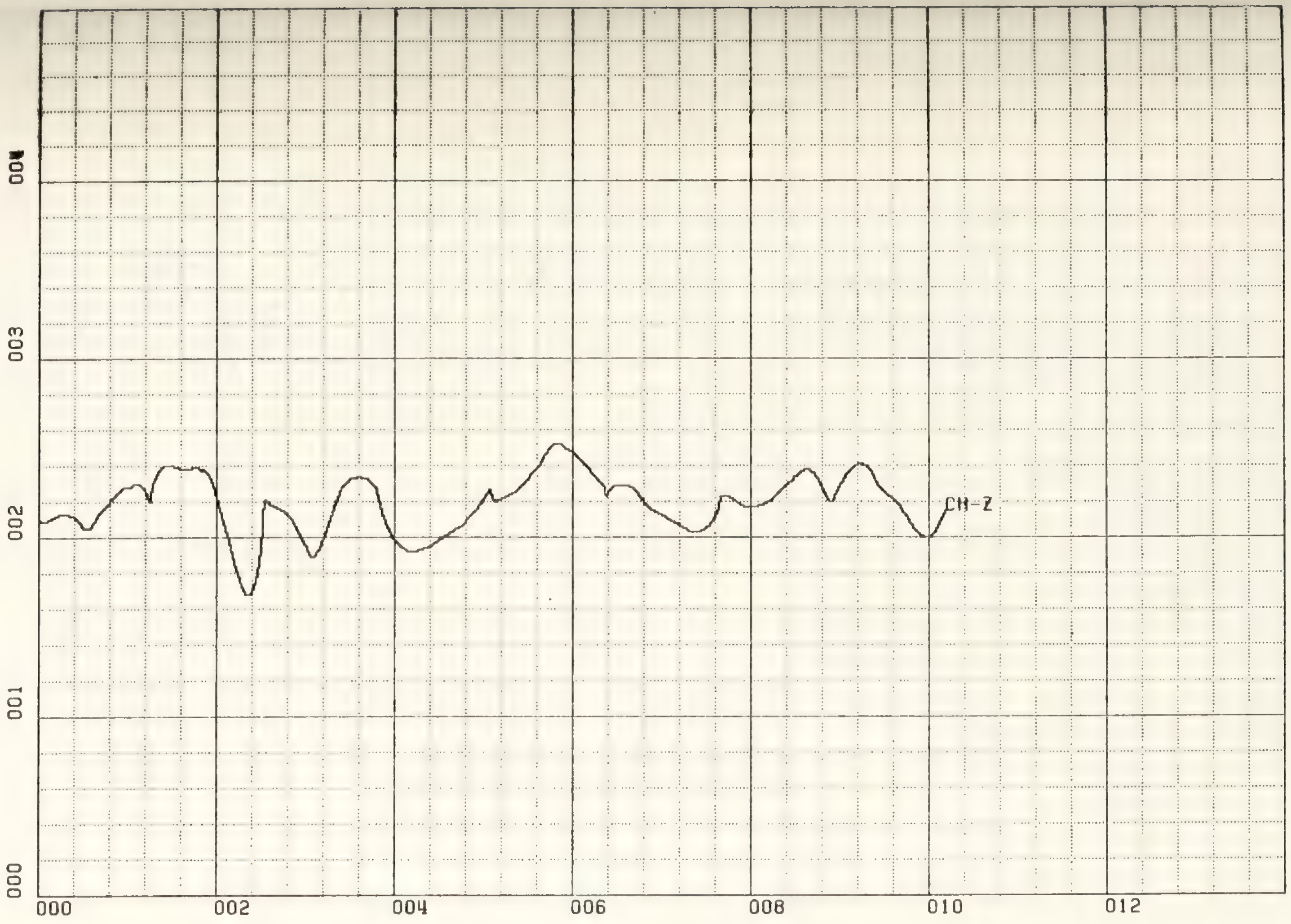

Figure 6.37 Z Coil Magnetic Field

Chew's Ridge, 1310 - 1317 Local

Field (10 nanoteslas/inch) vs Time (200 seconds/inch).

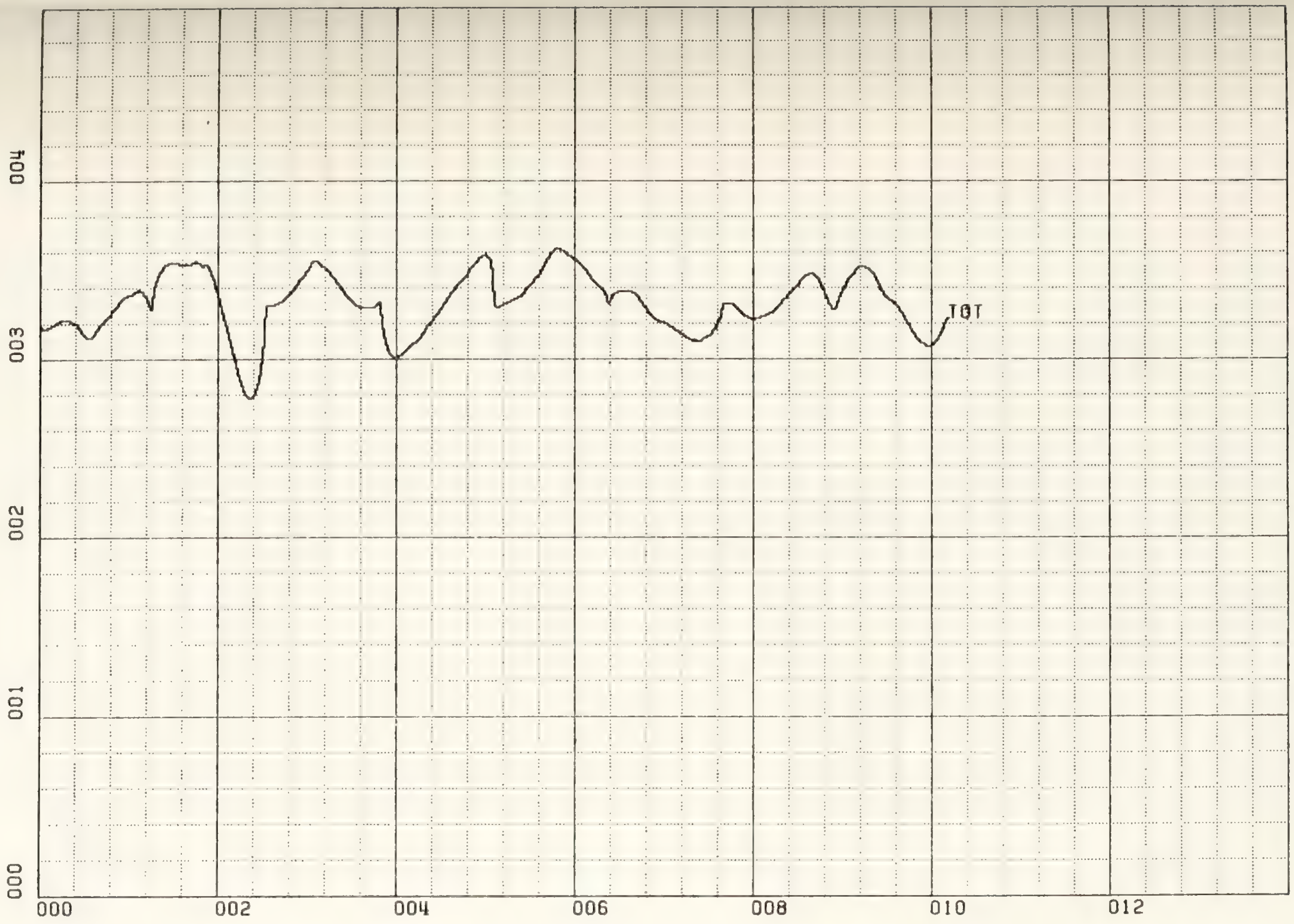

Figure 6.38 Total Magnetic Field

Chew's Ridge, 1310 - 1317 Local

Field (10 nanoteslas/inch) vs Time (200 seconds/inch).

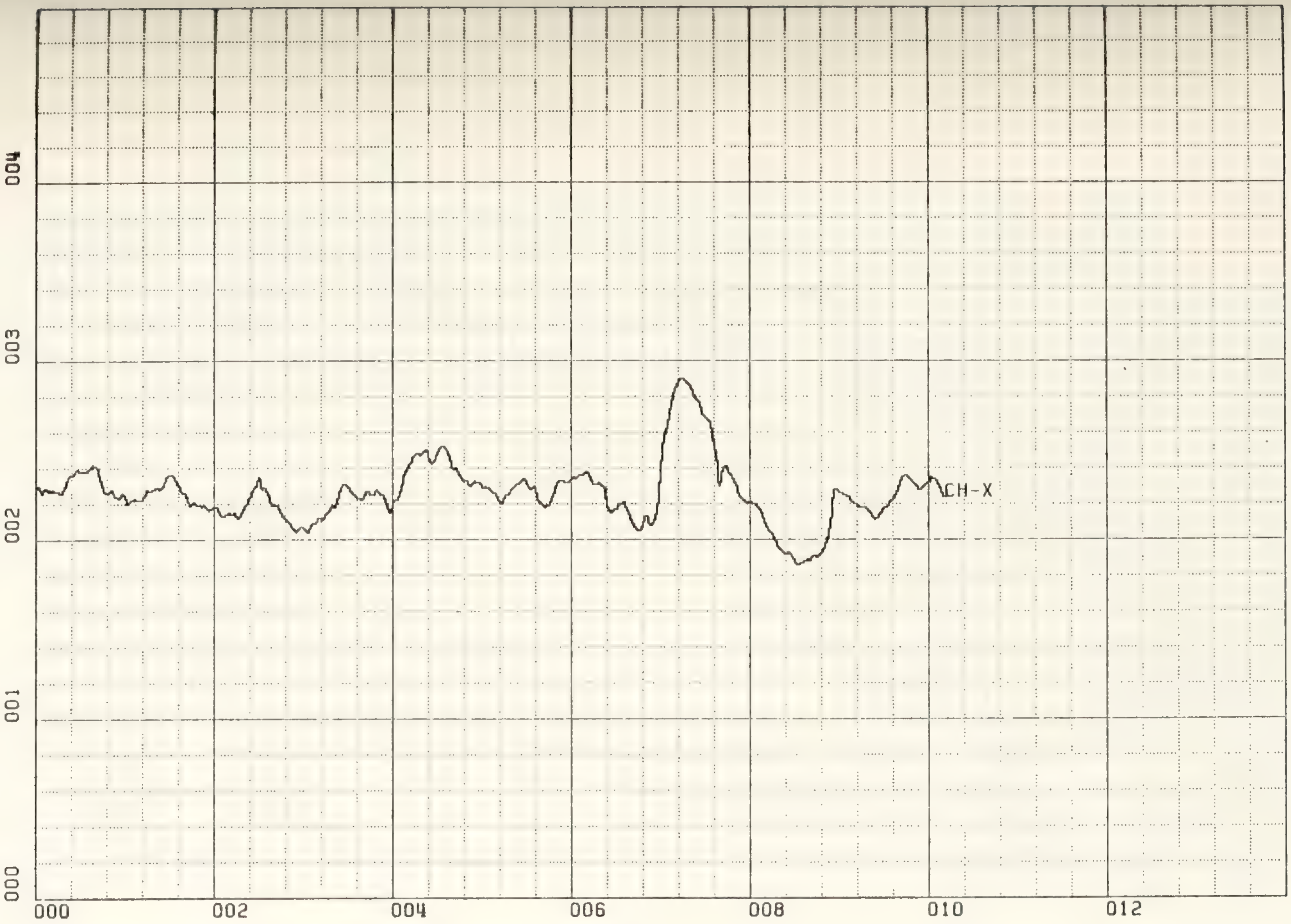

Figure 6.39 X Coil Magnetic Field

La Mesa Village, 1515 - 1532 Local

Field (1 nanotesla/inch) vs Time (200 seconds/inch).

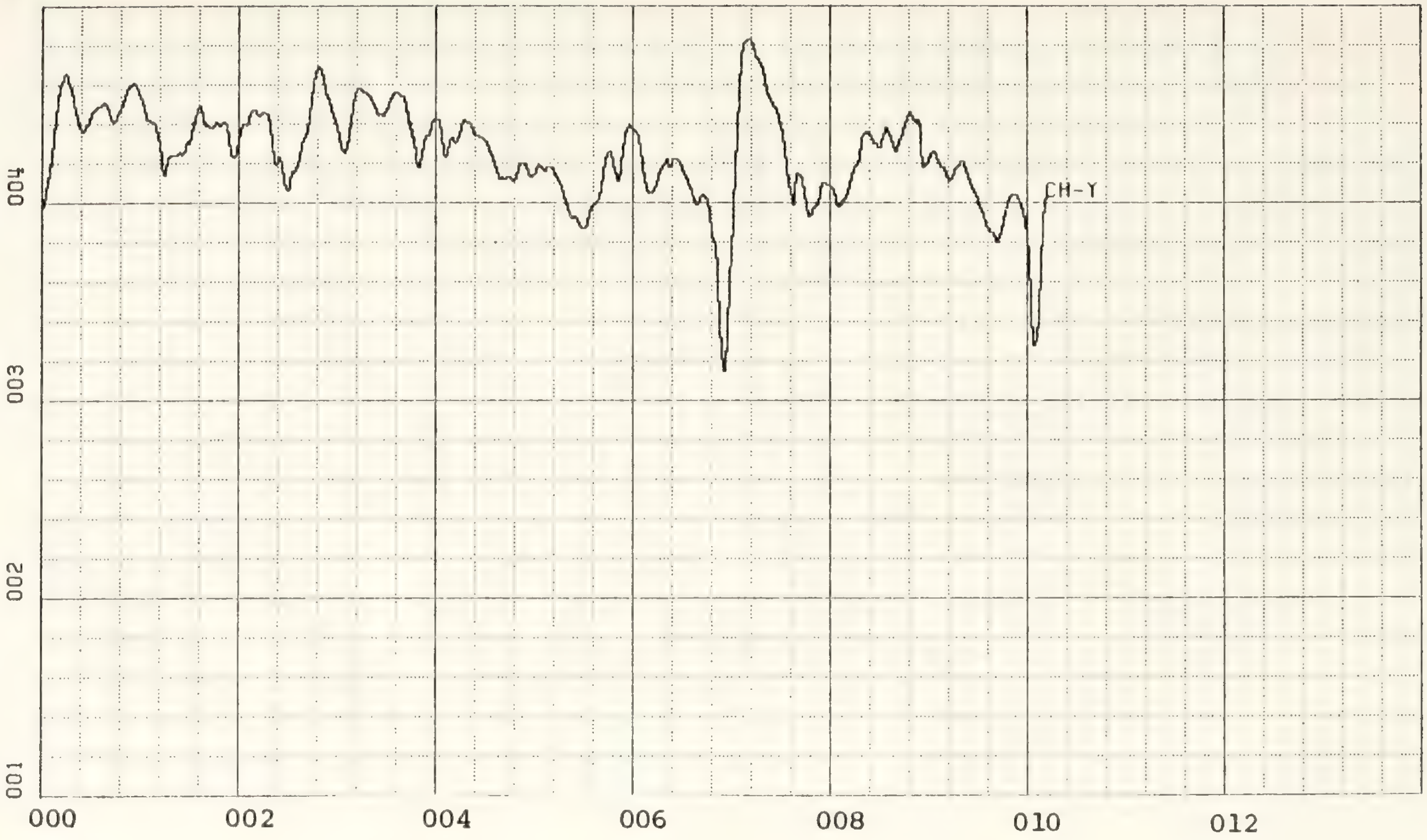

Figure 6.40 Y Coil Magnetic Field

La Mesa Village, 1515 - 1532 Local

Field (1 nanotesla/inch) vs Time (200 seconds/inch).

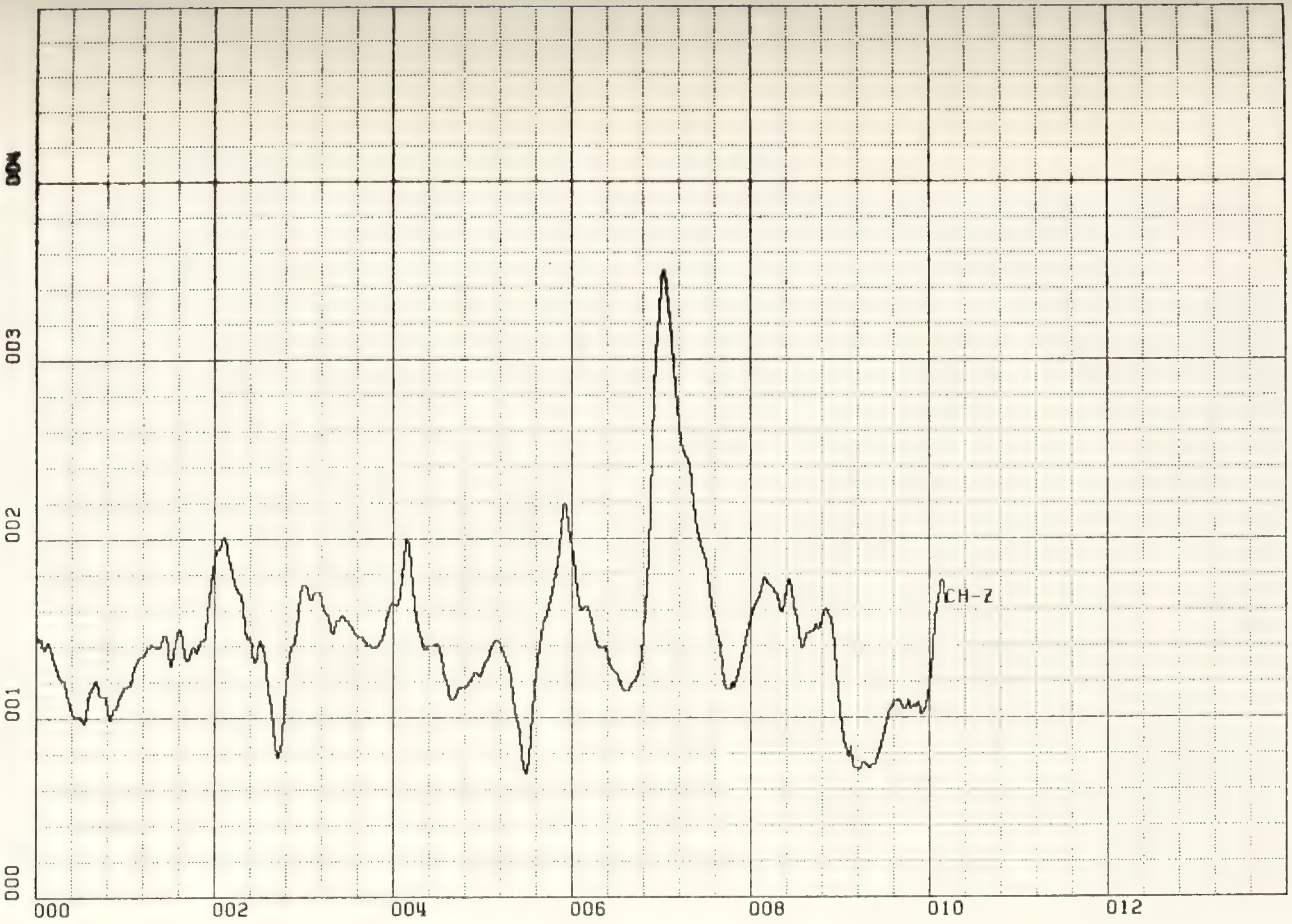

Figure 6.41 Z Coil Magnetic Field

La Mesa Village, 1515 - 1532 Local

Field (1 nanotesla/inch) vs Time (200 seconds/inch).

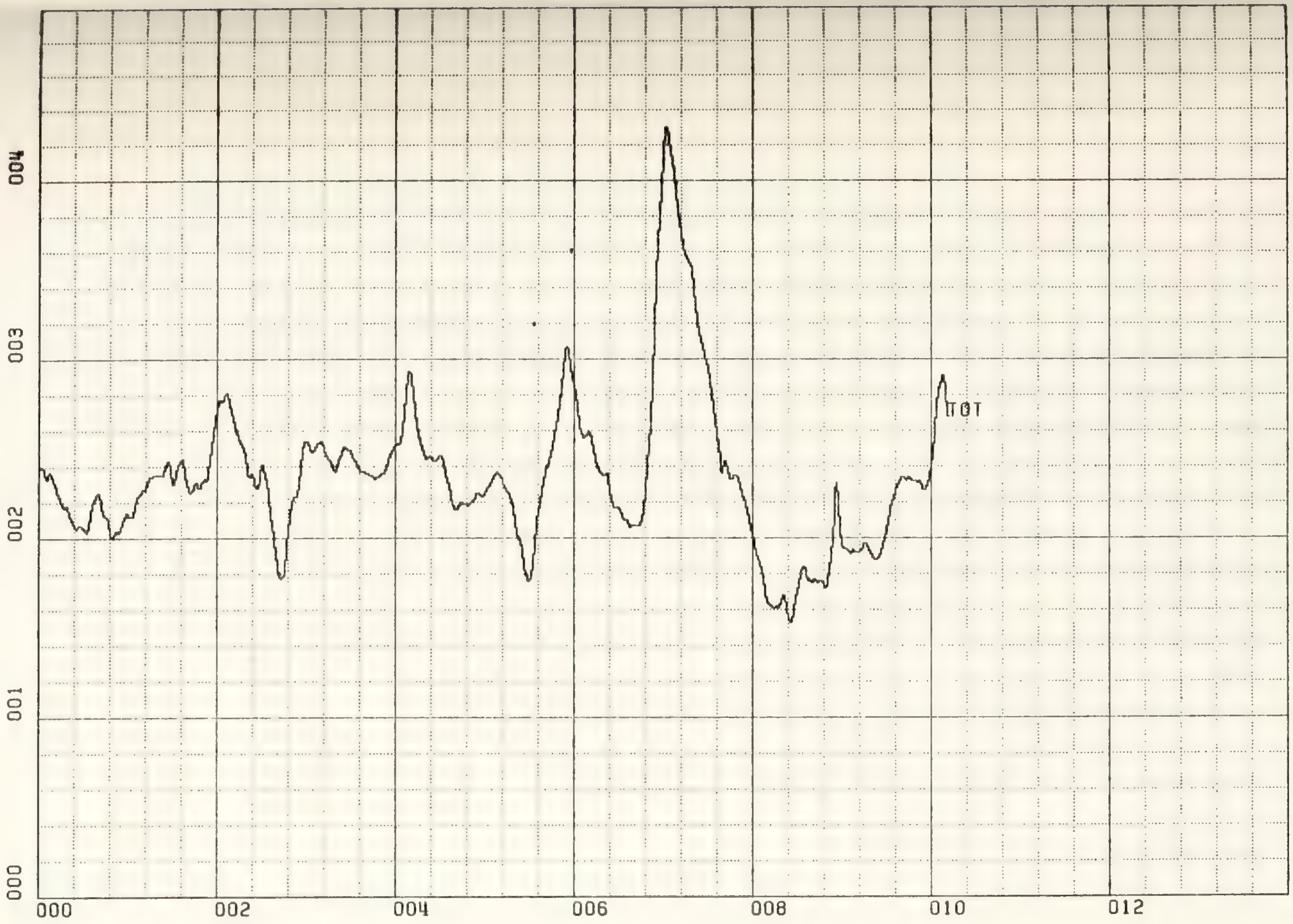

Figure 6.42 Total Magnetic Field

La Mesa Village, 1515 - 1532 Local

Field (1 nanotesla/inch) vs Time (200 seconds/inch).

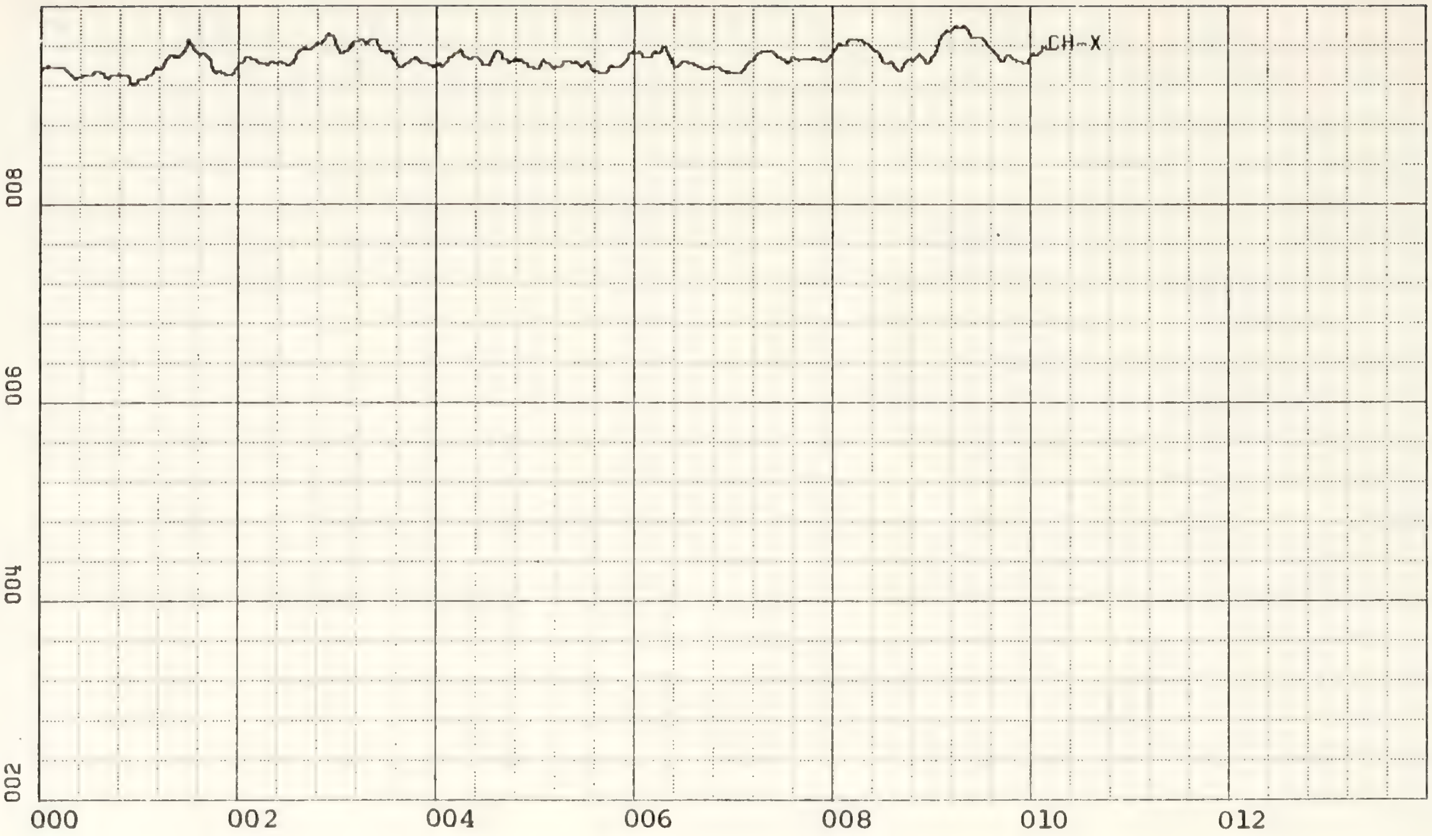

Figure 6.43 X Coil Magnetic Field

La Mesa Village, 1802 - 1819 Local

Field (2 nanotesla/inch) vs Time (200 seconds/inch).

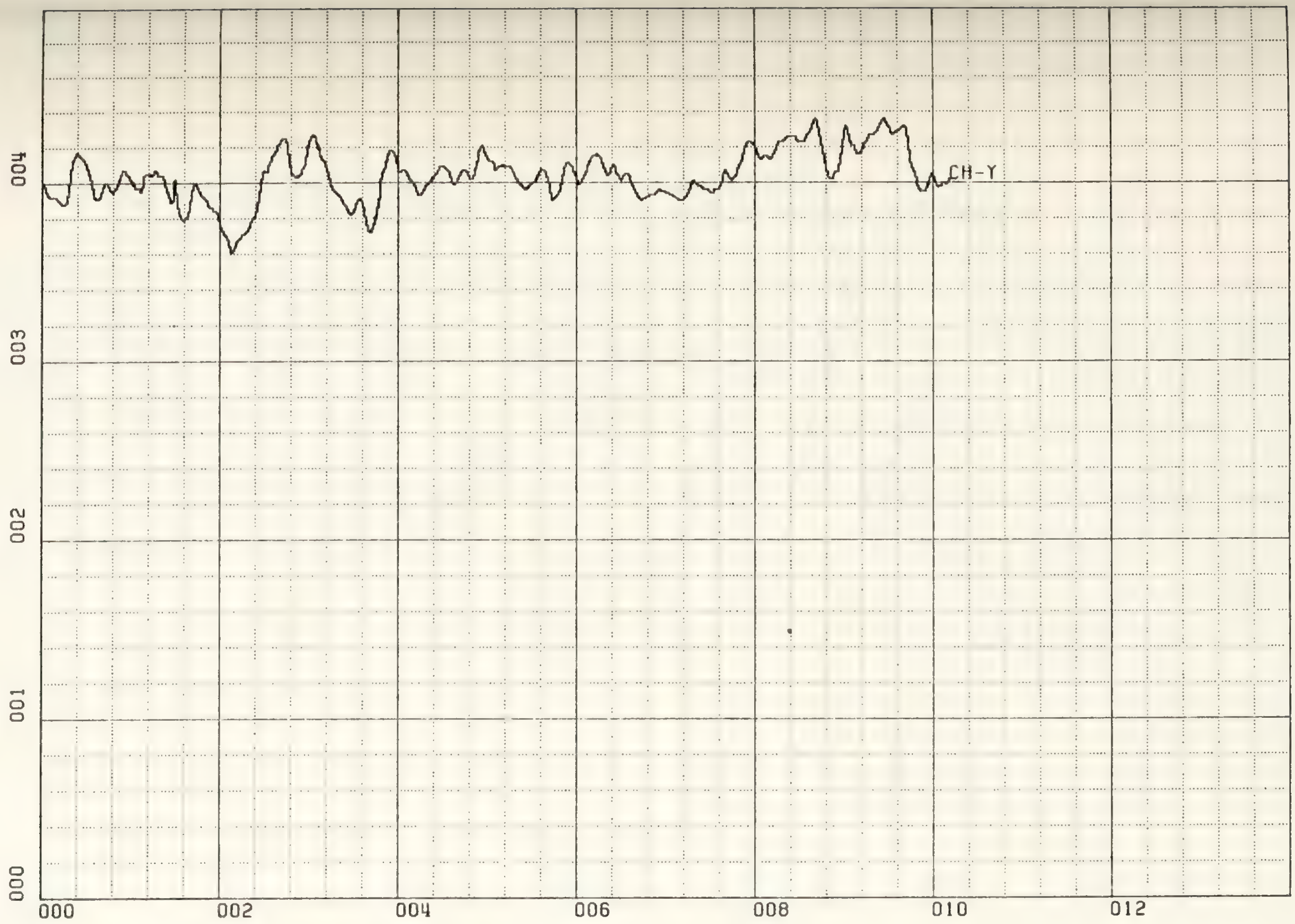

Figure 6.44 Y Coil Magnetic Field

La Mesa Village, 1802 - 1819 Local

Field (1 nanotesla/inch) vs Time (200 seconds/inch).

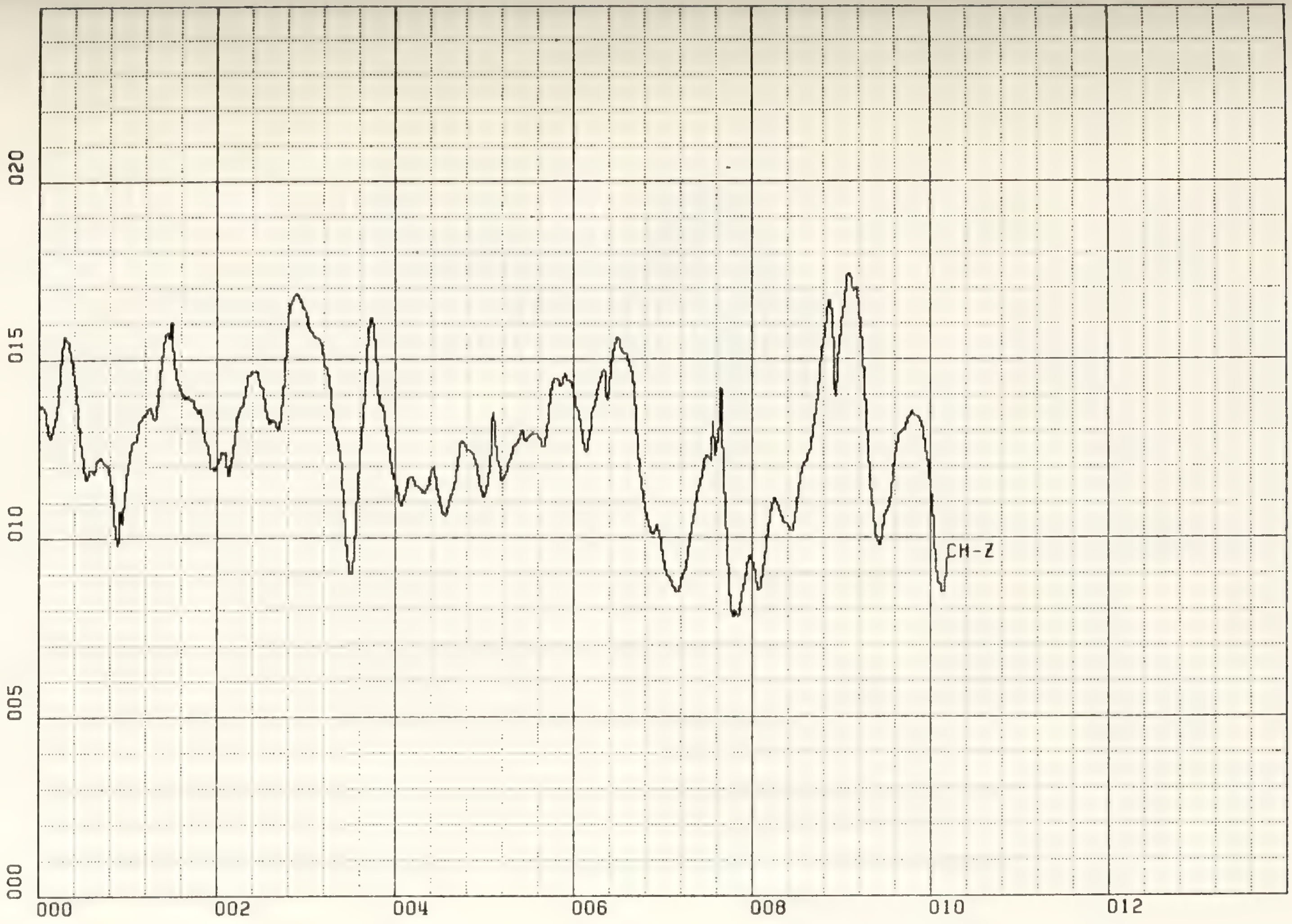

Figure 6.45 Z Coil Magnetic Field

La Mesa Village, 1802 - 1819 Local

Field (0.5 nanotesla/inch) vs Time (200 seconds/inch).

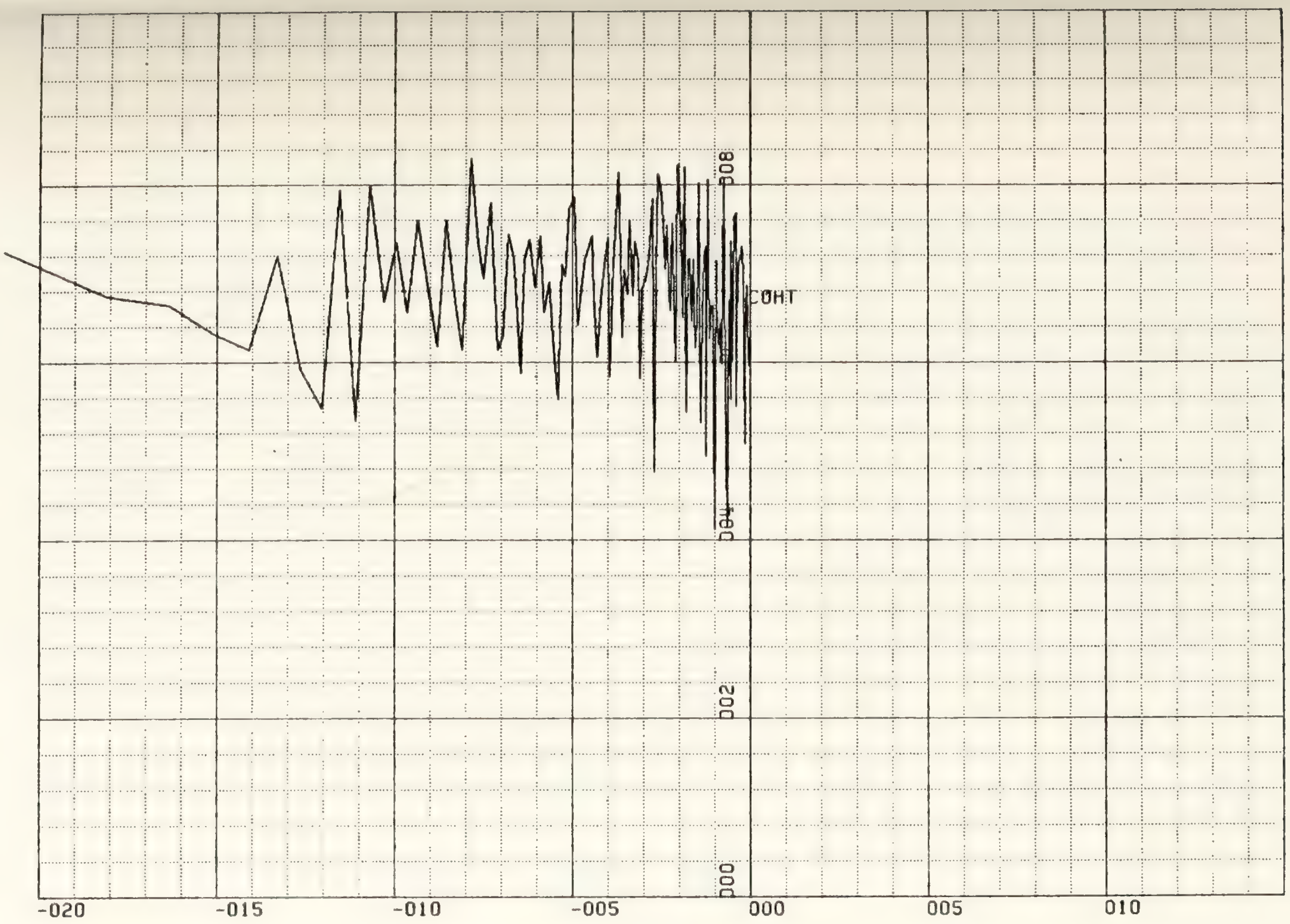

Figure 6.46   Total Field Coherence

1310 - 1350 Local

Coherence (0.2 units/inch) vs Log Frequency (0.5 Log Hz/inch).

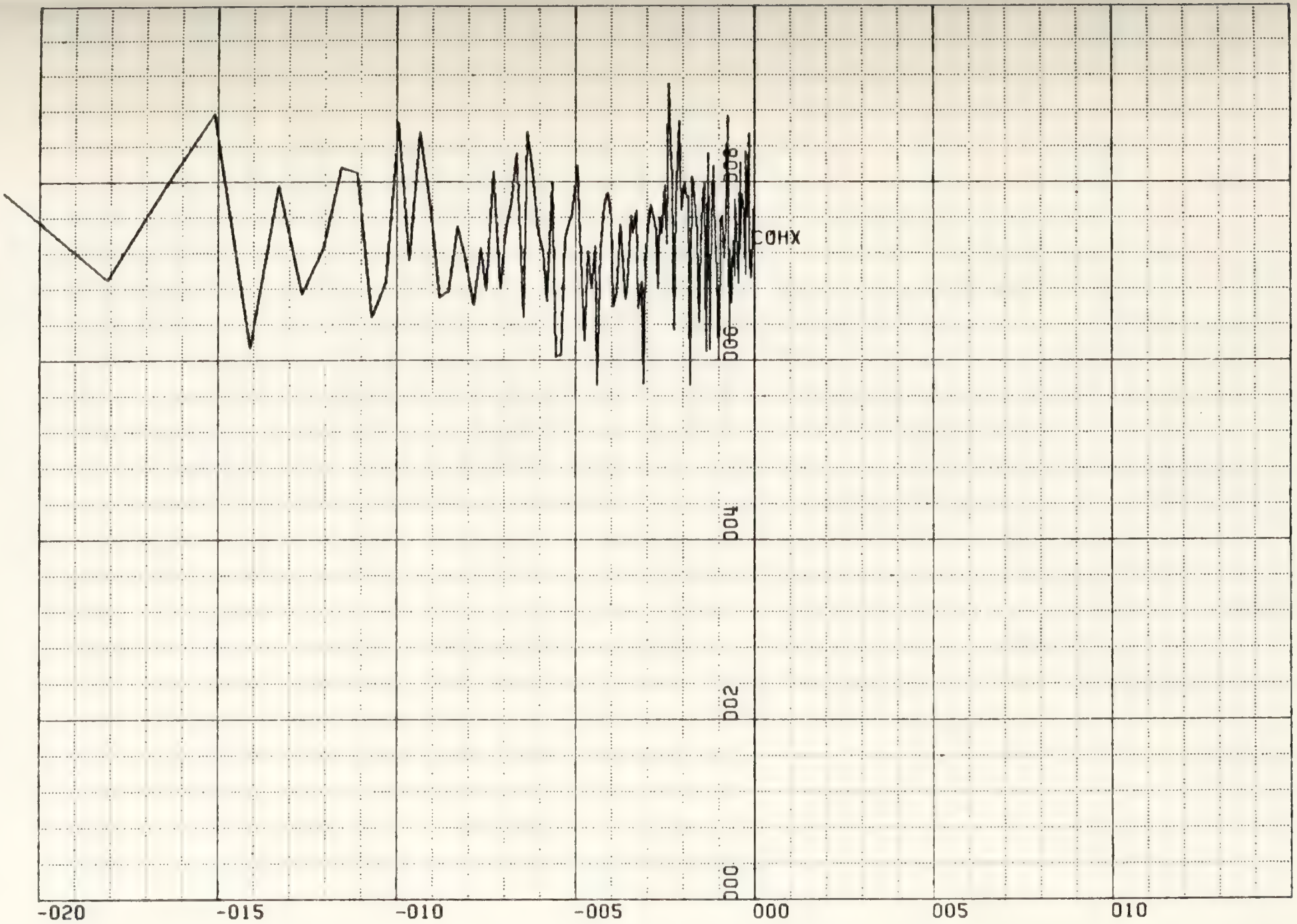

Figure 6.47 X Coil Coherence

1310 - 1350 Local

Coherence (0.2 units/inch) vs Log Frequency (0.5 Log Hz/inch).

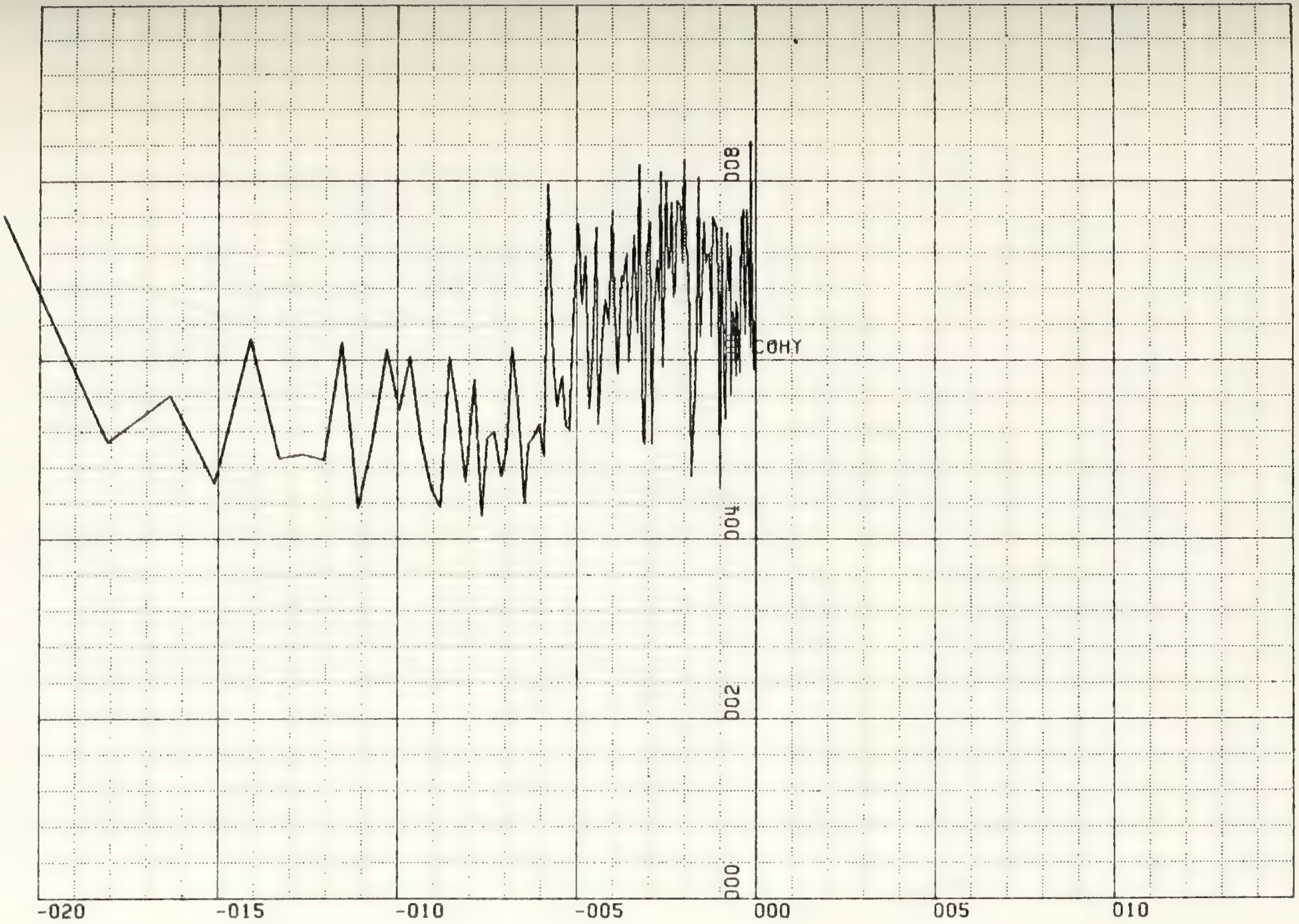

Figure 6.48 Y Coil Coherence

1310 - 1350 Local

Coherence (0.2 units/inch) vs Log Frequency (0.5 Log Hz/inch).

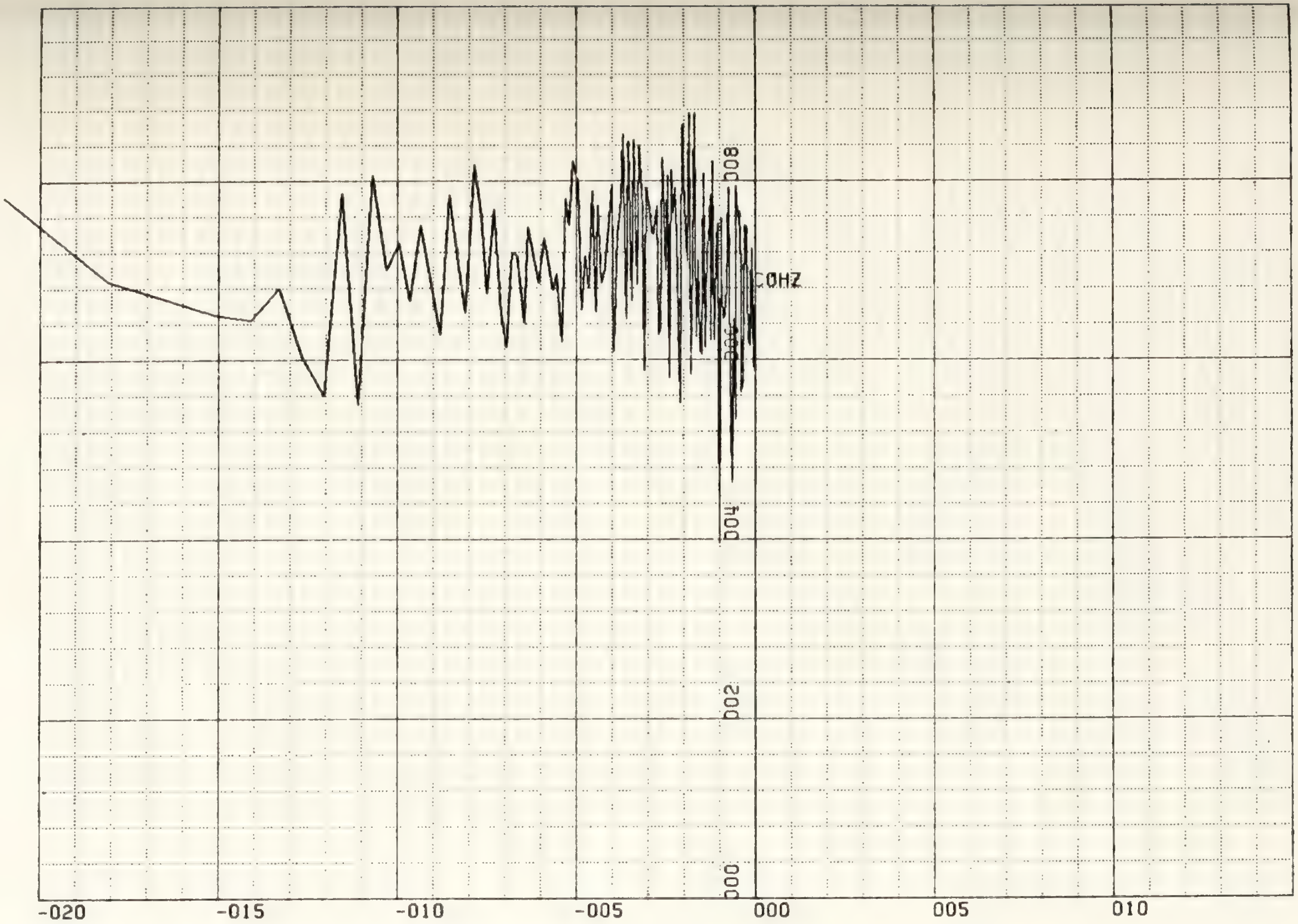

Figure 6.49 Z Coil Coherence

1310 - 1350 Local

Coherence (0.2 units/inch) vs Log Frequency (0.5 Log Hz/inch).

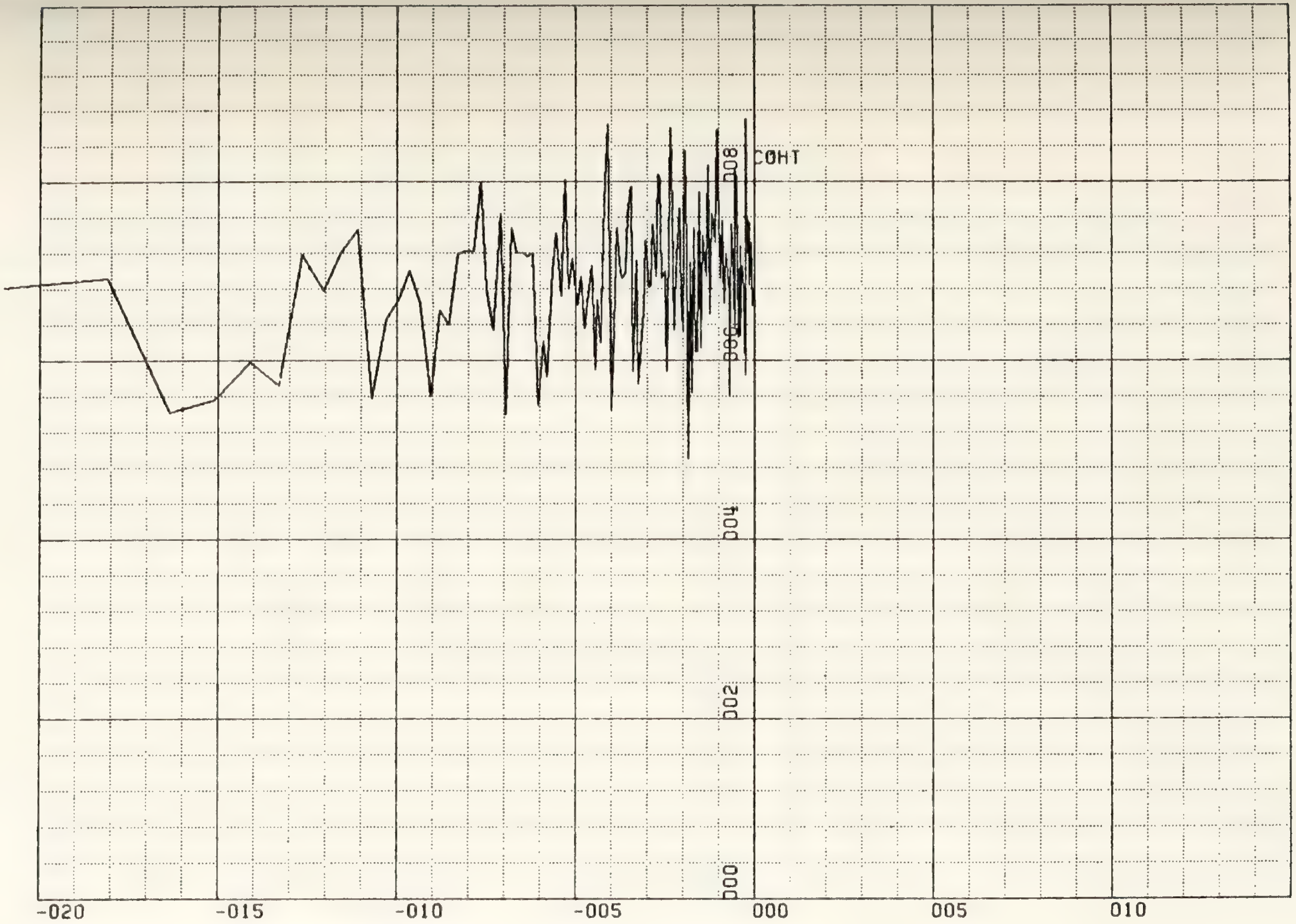

Figure 6.50 Total Field Coherence

1500 - 1540 Local

Coherence (0.2 units/inch) vs Log Frequency (0.5 Log Hz/inch).

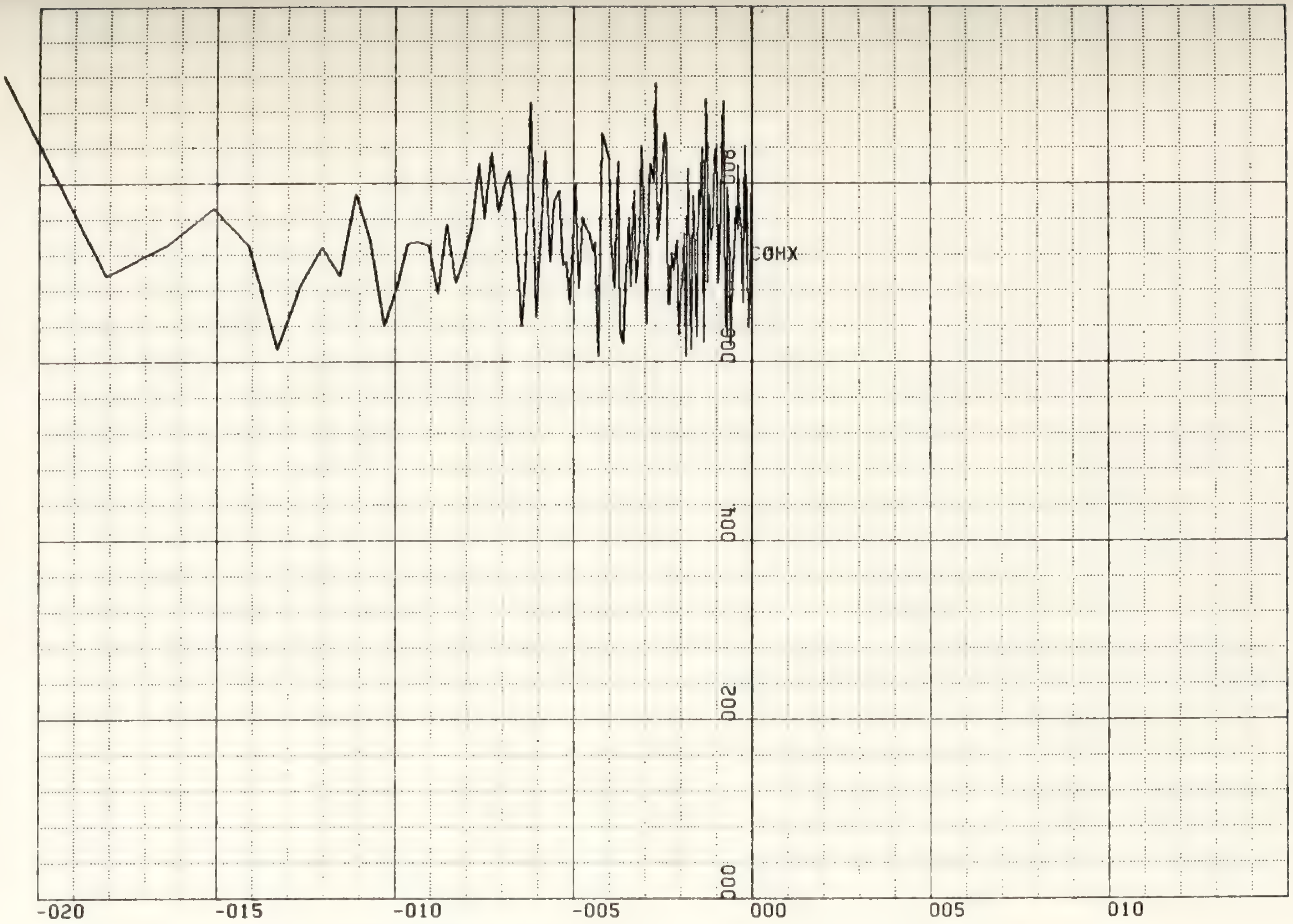

Figure 6.51 X Coil Coherence

1500 - 1540 Local

Coherence (0.2 units/inch) vs Log Frequency (0.5 Log Hz/inch).

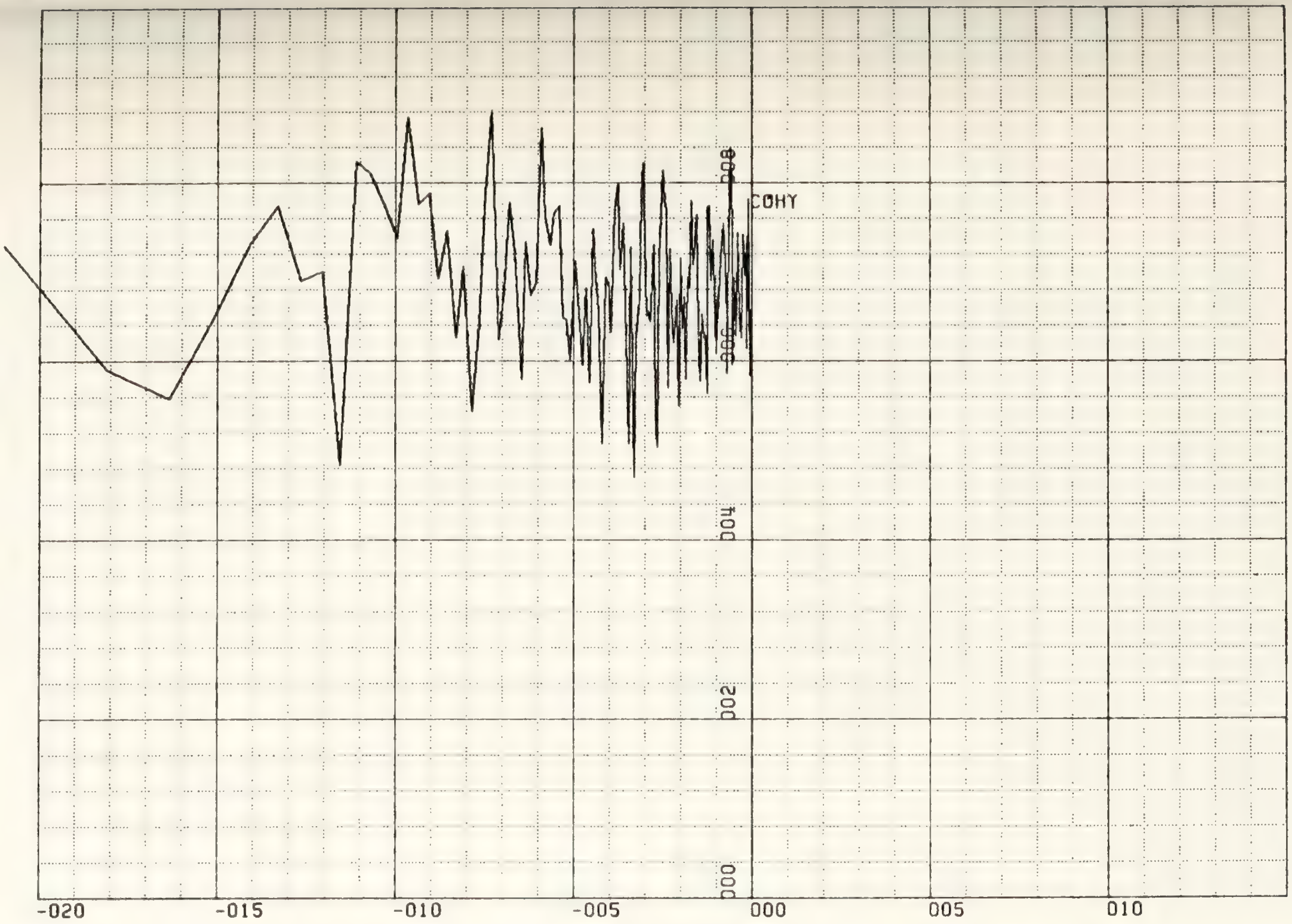

Figure 6.52 Y Coil Coherence

1500 - 1540 Local

Coherency (0.2 units/inch) vs Log Frequency (0.5 Log Hz/ inch).

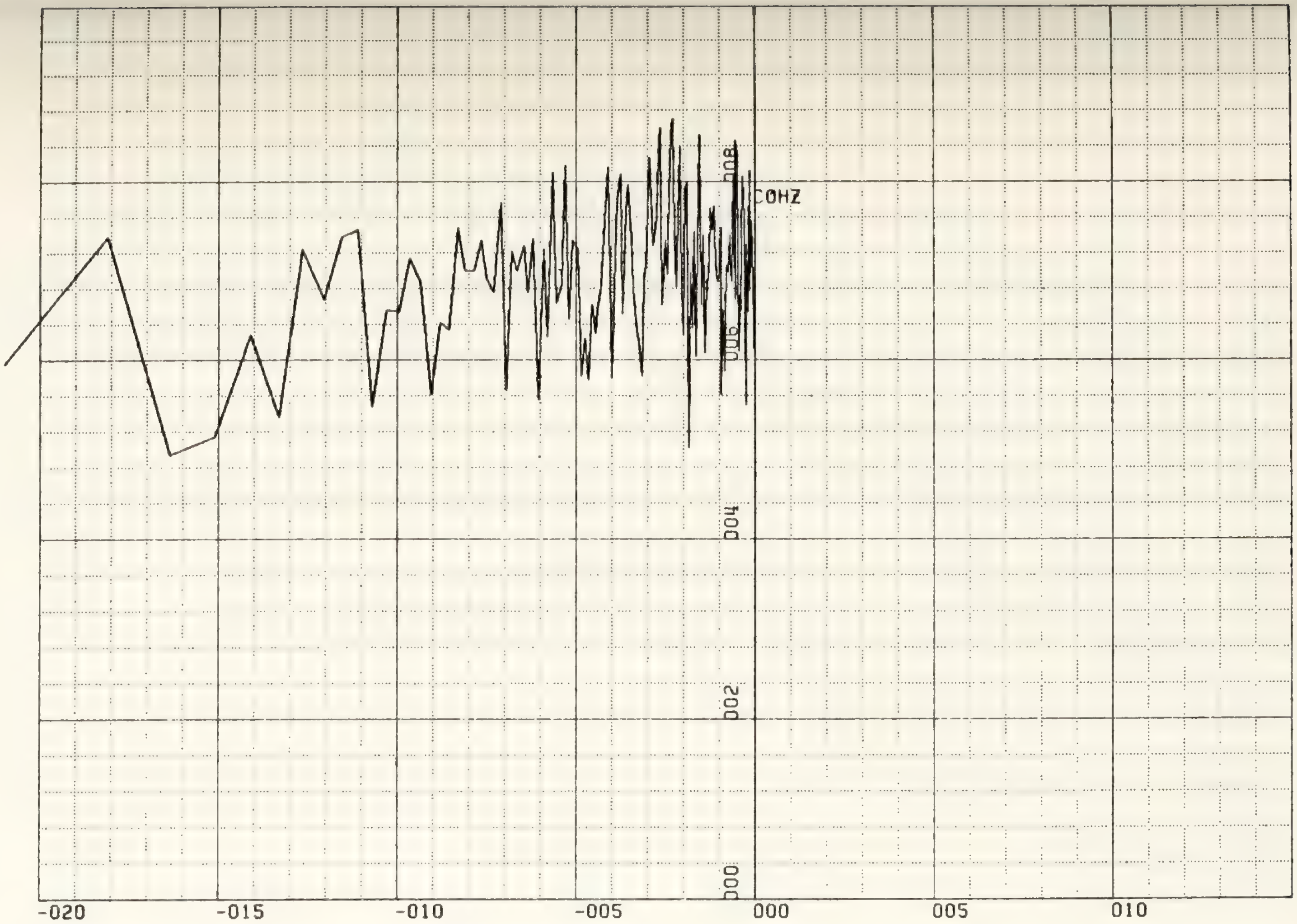

Figure 6.53 Z Coil Coherence

1500 - 1540 Local

Coherence (0.2 units/inch) vs Log Frequency (0.5 Log Hz/inch).

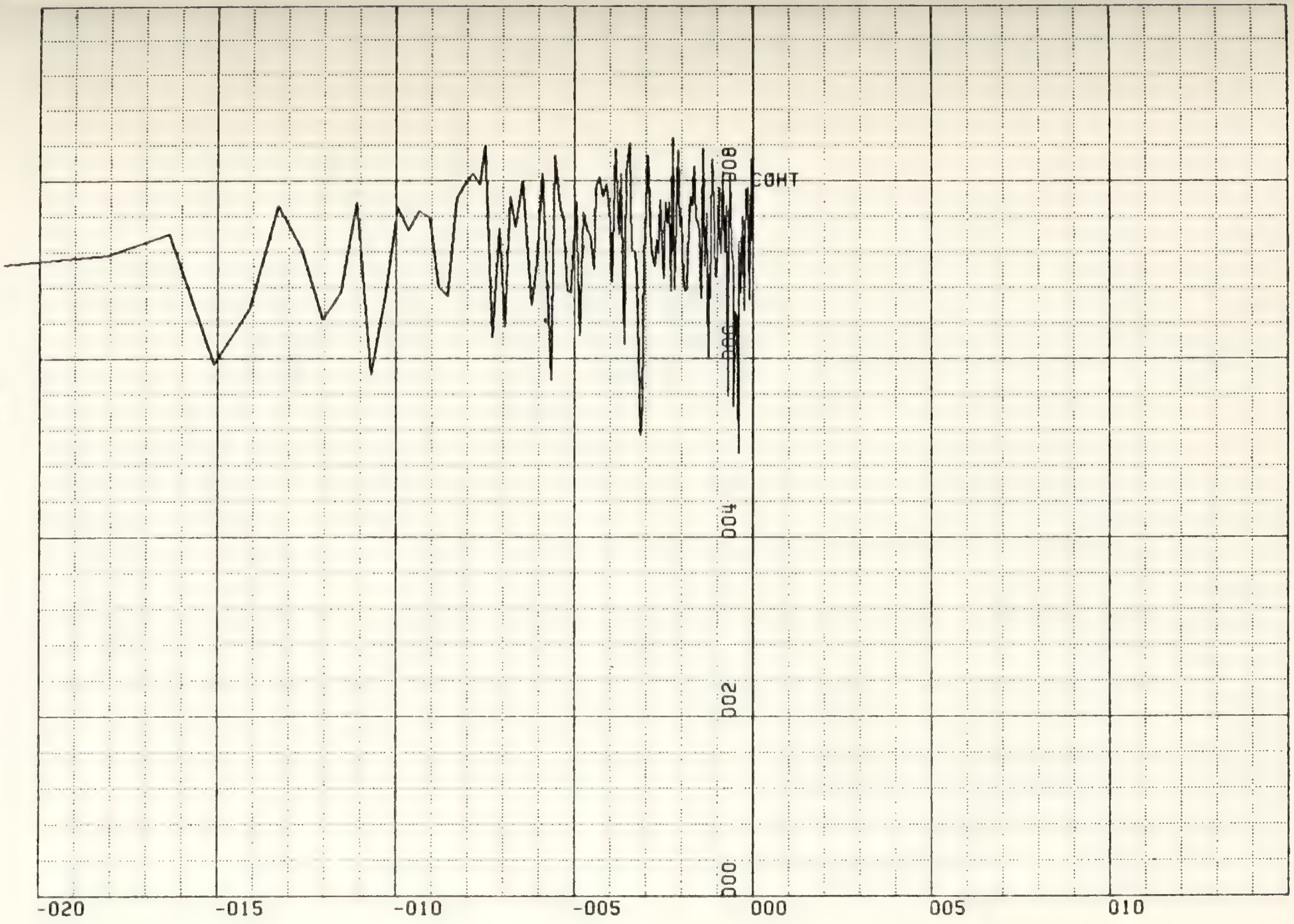

Figure 6.54 Total Field Coherence

1700 - 1740 Local

Coherence (0.2 units/inch) vs Log Frequency (0.5 Log Hz/inch).

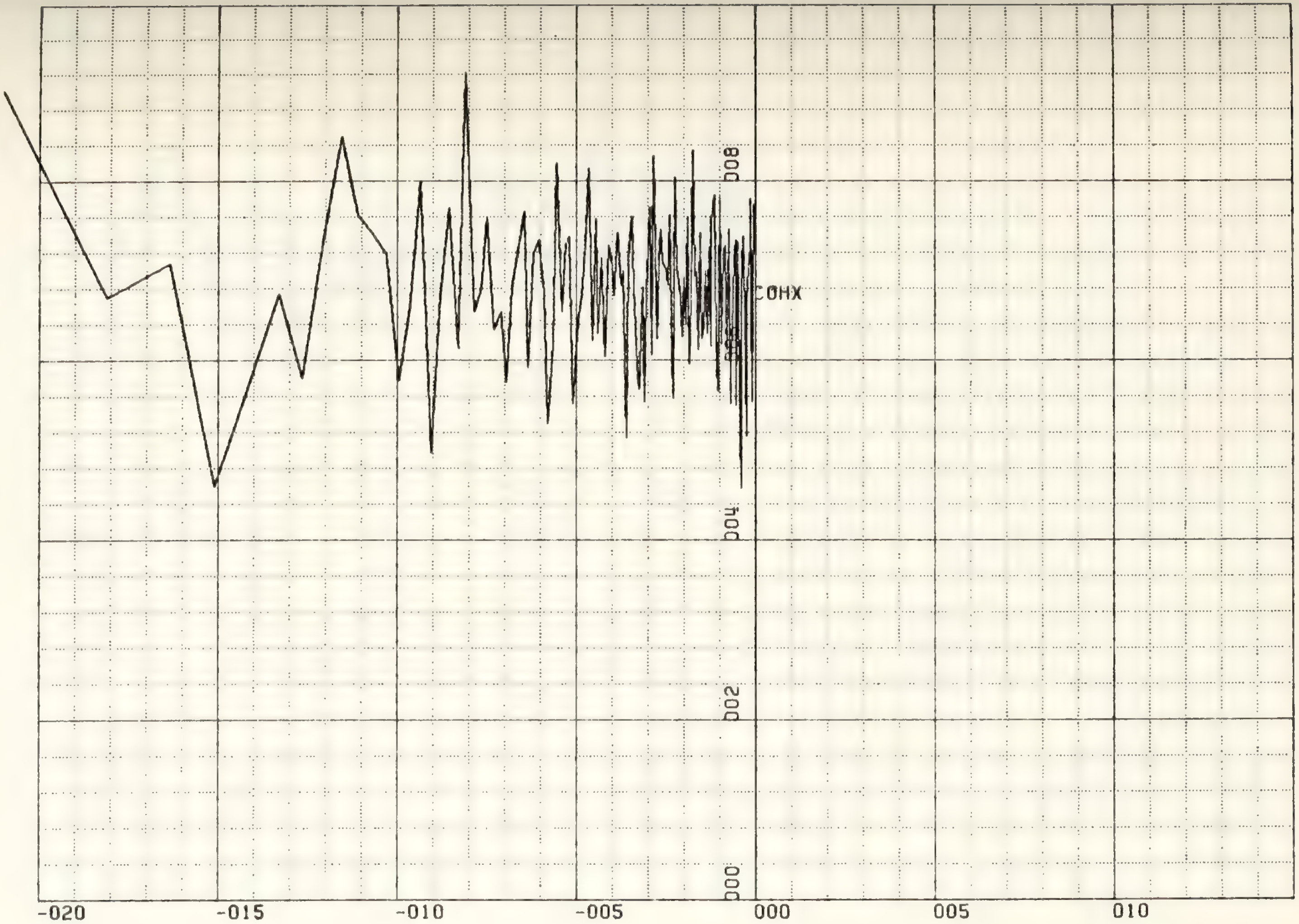

Figure 6.55 X Coil Coherence

1700 - 1740 Local

Coherence (0.2 units/inch) vs Log Frequency (0.5 Log Hz/inch).

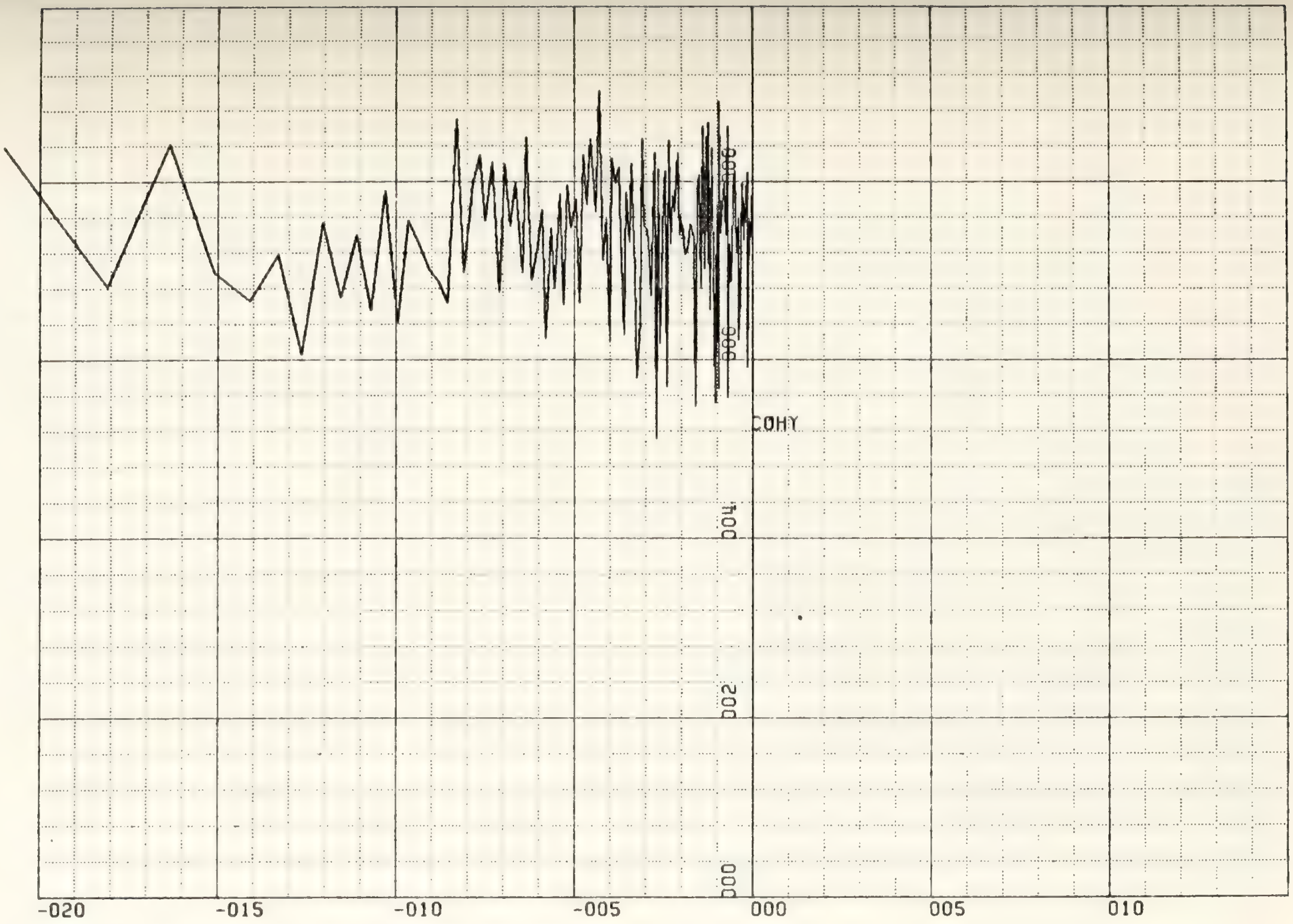

Figure 6.56 Y Coil Coherence

1700 - 1740 Local

Coherence (0.2 units/inch) vs Log Frequency (0.5 Log Hz/inch).

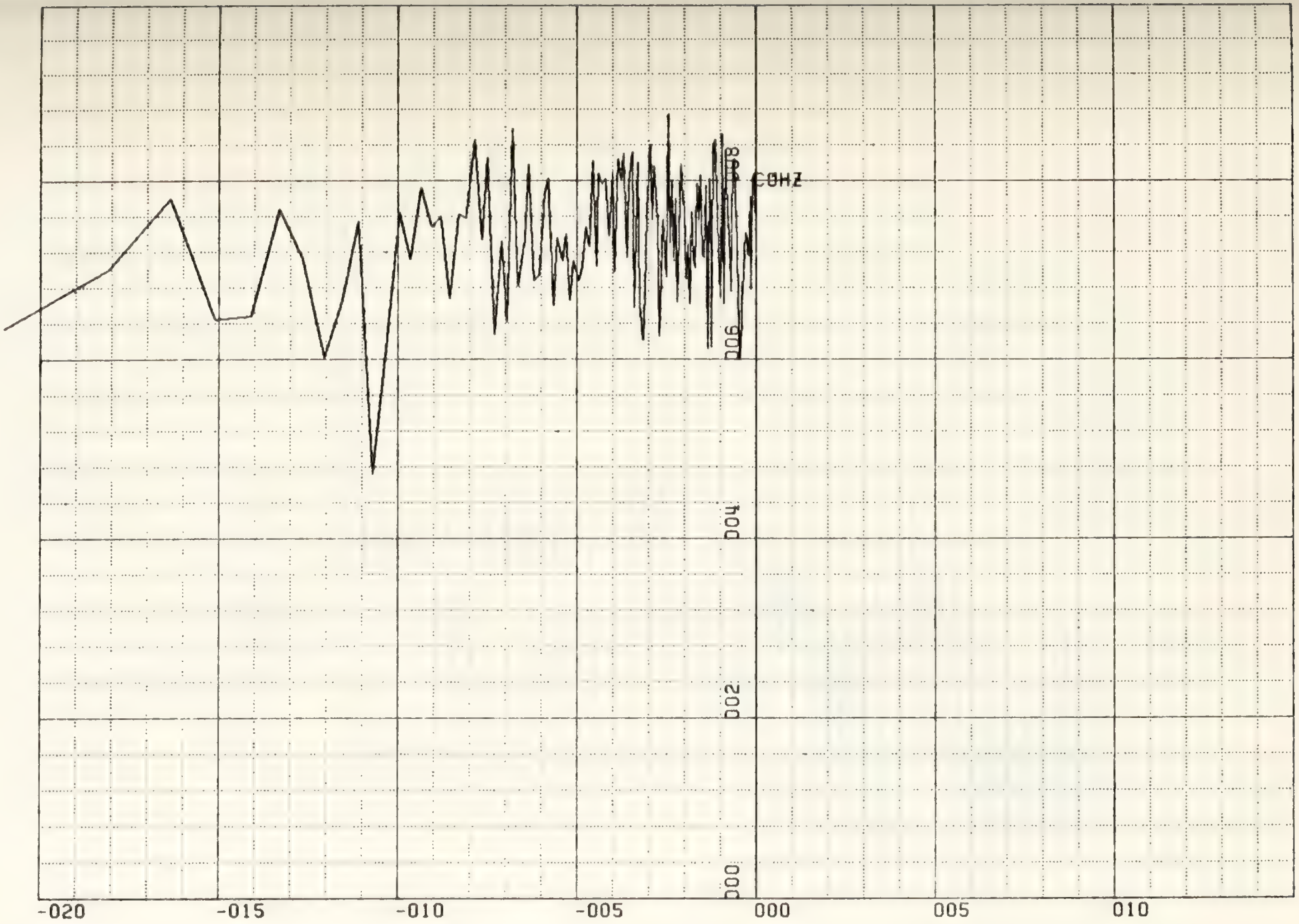

Figure 6.57 Z Coil Coherence

1700 - 1740 Local

Coherence (0.2 units/inch) vs Log Frequency (0.5 Log Hz/inch).

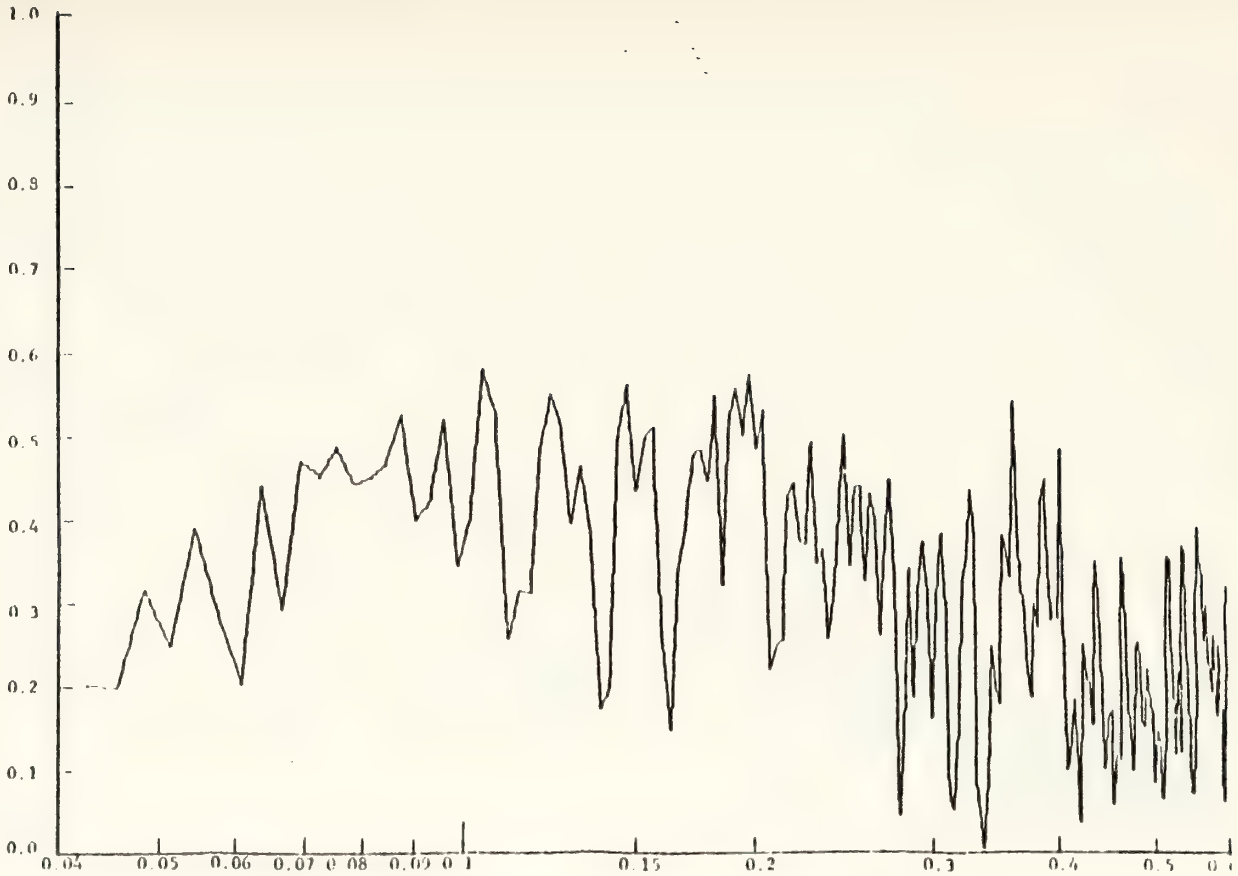

Figure 6.58 Total Field Coherence, NADC

11 July 1979, 1430 - 1630 Local

Coherence vs Frequency

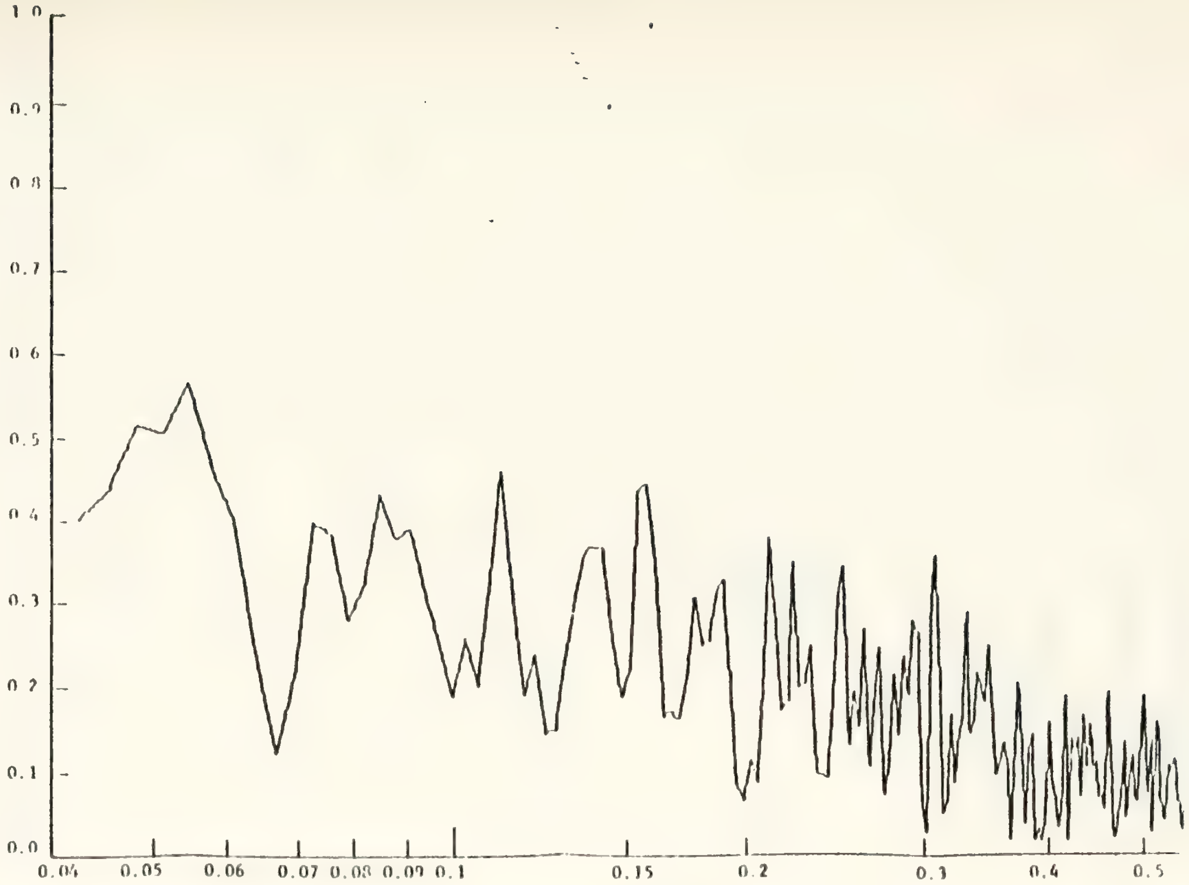

Figure 6.59 Total Field Coherence, NADC

11 July 1979, 1700 - 1900 Local

Coherence vs Frequency

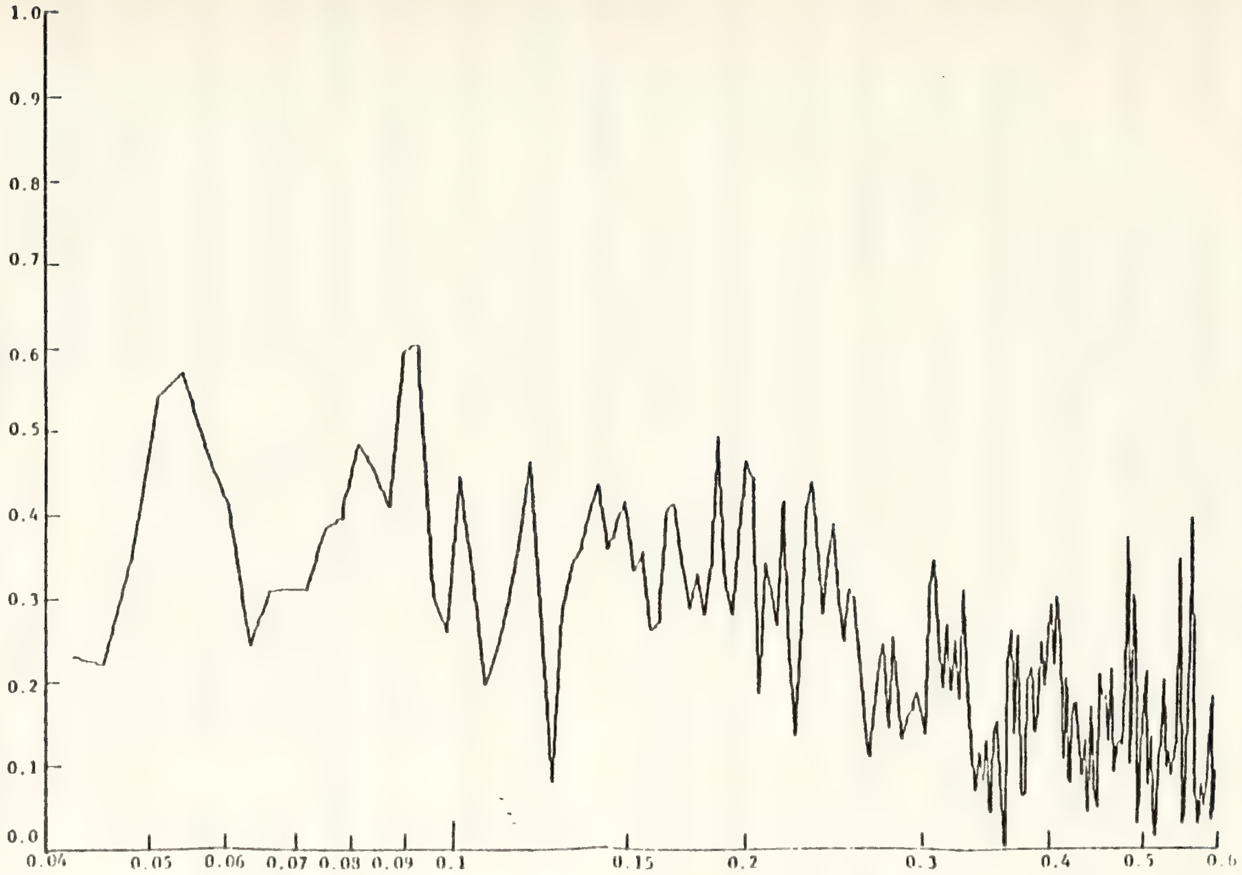

Figure 6.60 Total Field Coherence, NADC

11 July 1979, 1915 - 2115 Local

Coherence vs Frequency

VII. CONCLUSIONS AND RECOMMENDATIONS

A coherence of 0.6 - 0.8 in the background component of the geomagnetic field between 0.04 and 0.6 Hz was established. A coherence in this range should be considered only moderate. A lack of high coherence (0.9 - 1) indicates that the variations in the background field observed at the earth's surface at the two sites are not produced directly by the same source. However, the variations are clearly not random in nature. The moderate coherences found suggest that the source mechanisms for the background component in the geomagnetic field are complex and involve mechanisms in addition to or intermediate to simple fluctuations in the interplanetary magnetic field.

A discernable micropulsation was not recorded during the five hours of data taken. It is recommended that additional data be taken at the two sites in the hope of performing a coherence study on the micropulsation component of the geomagnetic field. It is also recommended that data be taken at additional sites of greater separation (100 km or more) in order to investigate the degree of coherence with distance.

APPENDIX A

SITE DESCRIPTION

The Chew's Ridge fire lookout is located 40 km southeast of the Naval Postgraduate School and at an altitude of approximately 3900 feet above sea level. It was chosen for its remoteness from the local power grid. Since the site is within the Los Padres National Forest, permission to collect data there had to be obtained from the National Forest Service. A dirt road provides easy access to the site for the transporting of equipment. The Monterey Institute for Research in Astronomy is currently constructing an observatory approximately one half mile from the lookout. What affect its presence will have on the suitability of the fire lookout for future data collection is not currently known.

Initial attempts to transmit the PCM data via a 170 MHz carrier wave from this site to the school proved impossible due to the relatively low transmission power used (3 watts), less than ideal line of sight, less than ideal antenna.

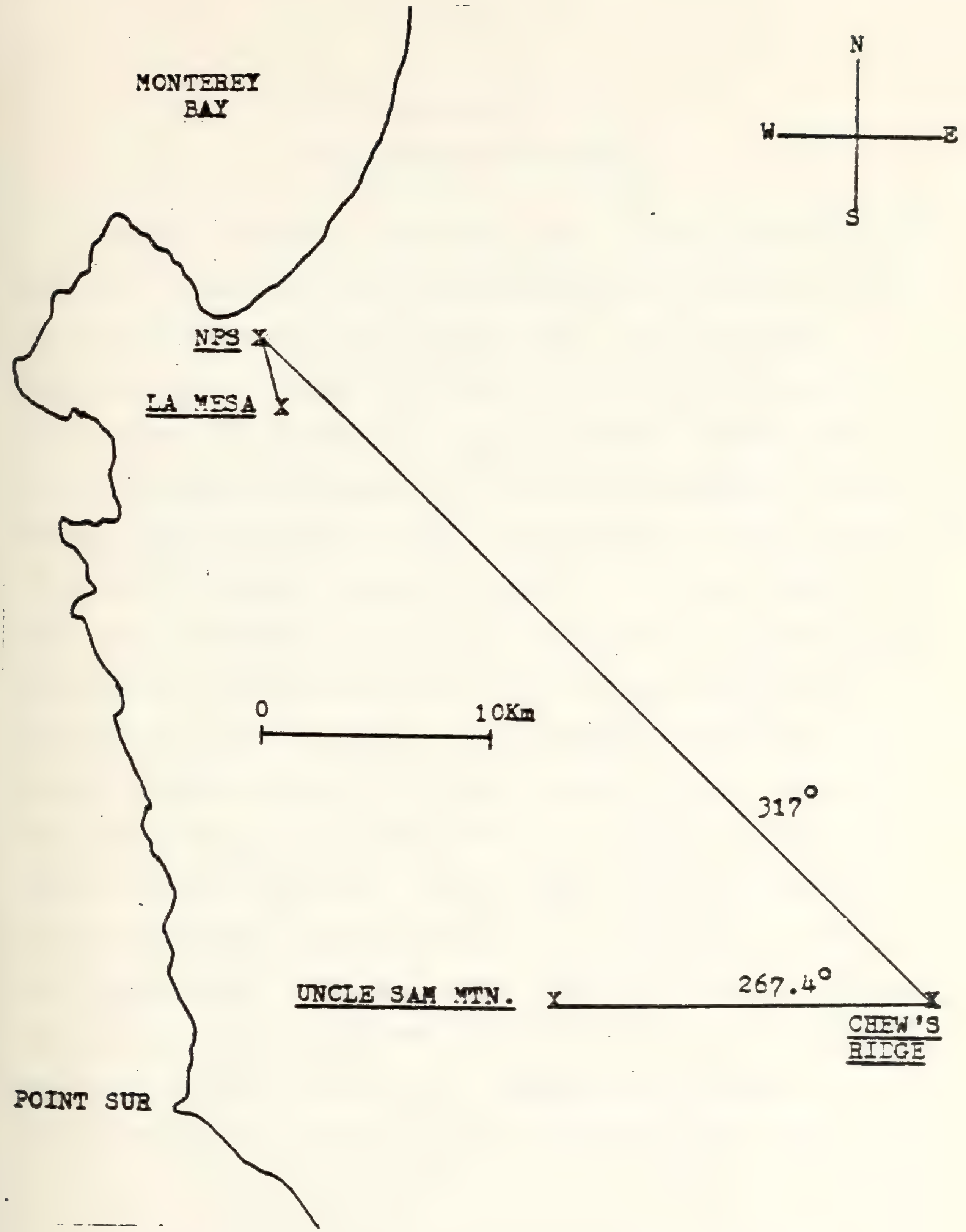

Figure A.1 Geographical Area of Data Collection.

APPENDIX B

PCM DECODING PROCEDURE

Several electronic components are utilized to decode the PCM data to digital form which is ultimately stored on nine track, 800 bits per inch digital tape. This data processing system is shown in Figure B.1. Central control of this process is accomplished with a Hewlett Packard 9845A computer utilizing an operator interactive program, "PCMPROG". After execution of the program, the computer requests entry of specific function control parameters into the computer and other equipment. These inputs are used to control synchronization of equipment start, digital tape drive speed, decode rate, decode time and synchronization code word entry into the decoder. The PCM encoded data is fed into the system from the HP 3964A/3968A tape recorder previously used to record the data. The decoding of the PCM data is accomplished with a Marine Profiles, Incorporated Model 319 PCM decoder. A Monsanto AM-6419/USM-368 oscilloscopes are used to display the PCM data. A Kennedy Model 9800 digital recorder and computer interface are employed to store the digital data on the nine track digital tape.

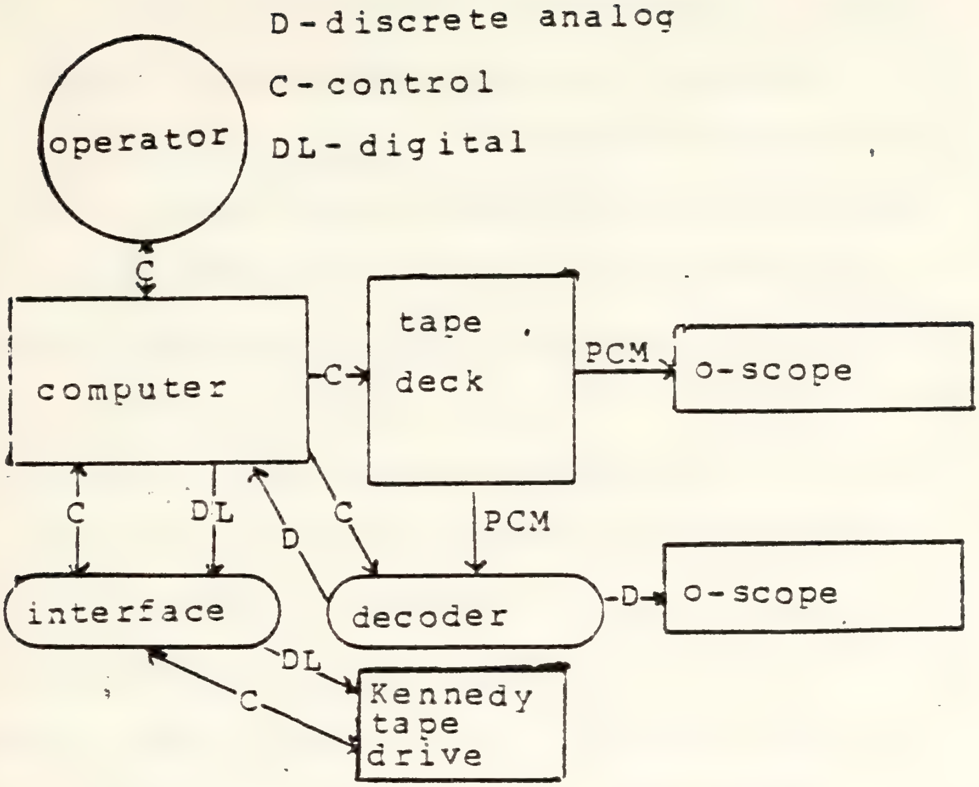

Figure B.1 Decoding System Data Flow and Control.

1. Decoding Procedure

a. Connect a coaxial cable between the output channel desired for decoding of the HP 3964A/3984A tape recorder and channel three of the Model 319 PCM decoder.

b. Energize the HP 3964A/3984A tape recorder, the Monsanto AM-6419/USM-368 oscilloscope, the Kennedy interface and the AANDERAA tape transfer interface, the Model 319 PCM decoder and the HP 9845A computer. Also, on the PCM Model 319 decoder place the fan toggle switch in the UP position and the AC/DC/OFF switch in the AC position.

c. Place into the right hand side tape reader of the HP 9845A computer the program named "PCM PROG". Type the command "MASS STORAGE IS":T15" and press EXECUTE. Then type the command GET "MT" and press EXECUTE.

d. On the PCM decoder place the following functions to the listed positions:

SOURCE - 3
SAMPLE RATE - 64 (for 3 3/4 recorder speed)
INVERT/NORMAL - NORMAL
OUTPUT/SAMPLE RATE - 0
RECORDS/FILE - INFINITY
SYNC CODE - 000

e. Press RUN on the computer, ignore the computer's response "enter Y to skip tape init" and press CONTINUE.

f. The computer now indicates "load tape" into the Kennedy unit and "put on line". To do this energize the Kennedy unit, place a write ring on the digital tape and load the tape according to the diagram located on the inside of the unit's door, press the LOAD button and the ON-LINE button located on the front of the unit.

g. The computer now indicates "enter synch code". Type into the computer 3658 (Chew's Ridge tapes) or 3155 (La Mesa Village tapes) and press CONTINUE.

h. Enter transfer time in minutes and seconds into the computer. For example 30 minutes and 50 seconds would be typed in as 30,50. Most analog tapes lasted 45 - 50 minutes. After this is done, press CONTINUE.

i. Push the STOP switch on the PCM decoder and press CONTINUE on the computer.

j. Push the PLAY button on the Hewlett Packard tape recorder, listening to the WWV time signal over a speaker or headphones. Push the START switch on the PCM decoder to begin the decoding process at a chosen time, using the second "ticks" of the time signal as a countdown. The decoding of the corresponding analog tape from the other recording site must be started at precisely the same time.

k. To end the data transfer early, push the K0 button on the computer. If this option is selected, "T" must be entered on the computer to write end of file on the digital tape.

l. "End of run" will be indicated on the computer CRT. Deenergize the equipment.

APPENDIX C

VOLTR COMPUTER PROGRAM

```
//CHFI19R JOB (2992,0165),'ANTHONY   SMC 2123',CLASS=G                  VOL00010
//*MAIN ORG=NPGVM1.2992P,LINES=(65)                                     VOL00020
//*FORMAT PR,DDNAME=PLOT.SYSVECTR,DEST=LOCAL                            VOL00030
// EXEC FRTXCLGP,PARM.LKED='LIST,MAP,XREF',REGION.GO=2048K              VOL00040
//FORT.SYSIN DD *                                                       VOL00050
C                                                                       VOL00060
C    THIS PROGRAM GENERATES ROUGH VOLTAGE VS TIME PLOTS. THE DATA IS    VOL00070
C    READ FROM A COMPUTER TAPE IN BLOCKS CONTAINING 8192 SAMPLES, OR    VOL00080
C    128 SECONDS, OF DATA.                                              VOL00090
      INTEGER*2 IN(16)                                                  VOL00100
C      ARRAY 'IN' IS USED IN READING DATA FROM TAPE                     VOL00110
      REAL*4 XX(8192),YY(8192),ZZ(8192)                                 VOL00120
C      THE ABOVE REAL*4 ARRAYS ARE USED TO ORDER INPUT DATA AND         VOL00130
C      INITIALLY REPRESENT VOLTAGE - TIME SERIES INFORMATION.           VOL00140
      DIMENSION ZZX1(65536),ZZY1(65536),ZZV1(65536)                     VOL00150
      DIMENSION TIME2(65536)                                            VOL00160
      INTEGER K,I5                                                      VOL00170
      INTEGER*4 ITB(12)/12*0/                                           VOL00180
      REAL*4    RTB(28)/28*0.0/                                         VOL00190
      REAL ALAB(3)/'CH-X','CH-Y','CH-Z'/                                VOL00200
      REAL*8 TITLE(12)                                                  VOL00210
      EQUIVALENCE(TITLE(1),RTB(5))                                      VOL00220
C      ARRAYS 'ITB','RTB','ALAB',AND 'TITLE' ARE USED IN GENERATING     VOL00230
C      THE VERTSATEC PLOTTER OUTPUT.                                    VOL00240
      DATA XX,YY/16384*0./                                              VOL00250
      DATA ZZ/8192*0./                                                  VOL00260
      K=0                                                               VOL00270
      I5=1                                                              VOL00280
      DO 31 IN1=1,65536                                                 VOL00290
      ZZX1(IN1)=0.0                                                     VOL00300
      ZZY1(IN1)=0.0                                                     VOL00310
      ZZV1(IN1)=0.0                                                     VOL00320
      TIME2(IN1)=0.0                                                    VOL00330
   31 CONTINUE                                                          VOL00340
C       THE NEXT FIVE LINES SERVE AS A TIME DELAY IN STARTING THE       VOL00350
C       DATA ANALYSIS. ISEC IS THE NUMBER OF SECONDS DELAYED.           VOL00360
      ISEC=10                                                           VOL00370
      ITL=ISEC*64                                                       VOL00380
      DO 55 JJ=1,ITL                                                    VOL00390
      CALL RD(20,IN,200,IREC,IRR)                                       VOL00400
   55 CONTINUE                                                          VOL00410
      IFRAME=8192                                                       VOL00420
C      THE VALUE OF NR DETERMINES THE NUMBER OF DATA BLOCKS THE ARE     VOL00430
C      READ AND ANALYZED.                                               VOL00440
      NR=8                                                              VOL00450
      FNR=FLOAT(NR)                                                     VOL00460
      DO 70 L1=1,NR                                                     VOL00470
C      THE DO LOOP ENDING WITH STATEMENT 70 ENABLES THE PROGRAM TO      VOL00480
```

```
C        PROCESS A LARGE AMOUNT OF DATA BY REPEATING THE PROCESS IN
C        BLOCKS.
C        'NR' REPRESENTS THE NUMBER OF DATA SEQUENCES. ONE
C        SEQUENCE CURRENTLY EQUALS 8192 DATA POINTS FOR EACH CHANNEL
C        OR 128 SECONDS OF DATA.
C
C         THE DO LOOP ENDING WITH 60 READS THE DATA FROM THE PCM FRAME
C         STRIPS OUT THE SYNC CODE, AND SORTS OUT THE DATA BY COIL
C         CHANNEL.
      DO 60 JJ=1,IFRAME
      CALL RD(20,IN,1000,IREC,IRR)
      XX(JJ)=IN(2)
      YY(JJ)=IN(3)
      ZZ(JJ)=IN(4)
   60 CONTINUE
      N=8192
      FN=FLOAT(N)
      DELTAT=1./64.
      DO 20 J=1,N
C     THE FOLLOWING CALCULATIONS NORMALIZE THE DATA TO +5V AND -5V.
      XX(J)=((XX(J)-2048.)*5./2048.)
      YY(J)=((YY(J)-2048.)*5./2048.)
      ZZ(J)=((ZZ(J)-2048.)*5./2048.)
C        'XX' IS THE X-COIL DATA, 'YY' IS THE Y-COIL DATA,
C        'ZZ' IS THE Z-COIL DATA
C        NORTH-SOUTH COMPONENT (XX) AND THE VERTICAL COMPONENT (ZZ)
   20 CONTINUE
C        THE FOLLOWING LOOP PUTS THE DATA FROM EACH 8192-SAMPLE ARRAY
C        INTO ONE CONTINUOUS NR*8192 SAMPLE ARRAY
      DO 91 I3=1,8192
      ZZX1(I5)=XX(I3)
      ZZY1(I5)=YY(I3)
      ZZV1(I5)=ZZ(I3)
      TIME2(I5)=(DELTAT*FLOAT(I3))+(128.0*FLOAT(K))
      I5=I5+1
   91 CONTINUE
      K=K+1
   70 CONTINUE
C
C    VERSATEC PLOT OF V - TIME SERIES VOLTAGE
C
      NPTS=1020./DELTAT +1.
C        'NPTS' DETERMINES NUMBER OF POINTS NECESSARY IN ORDER FOR
C         THE 0 TO NPTS  SECS RANGE TO BE PLOTTED.
C        FOR THE FOLLOWING 'ITB' AND 'RTB' VALUES REVIEW THE WRITE-UP
C        FOR THE SUBROUTINE PROCEDURE 'DRAWP'.
      ITB(3)=20
      ITB(4)=8
```

```
      ITB(7)=1
      ITB(12)=0
      RTB(1)=0.0
      RTB(2)=0.0
      RTB(3)=ALAB(1)
      READ(5,3000)TITLE
      CALL DRAWP(NPTS,TIME2,ZZX1,ITB,RTB)
      RTB(3)=ALAB(2)
      READ(5,3000)TITLE
      CALL DRAWP(NPTS,TIME2,ZZY1,ITB,RTB)
      RTB(3)=ALAB(3)
      READ(5,3000)TITLE
      CALL DRAWP(NPTS,TIME2,ZZV1,ITB,RTB)
      ITB(3)=7
      ITB(4)=5
      ITB(12)=0
      RTB(3)=ALAB(1)
      READ(5,3000)TITLE
      CALL DRAWP(NPTS,TIME2,ZZX1,ITB,RTB)
      RTB(3)=ALAB(2)
      READ(5,3000)TITLE
      CALL DRAWP(NPTS,TIME2,ZZY1,ITB,RTB)
      RTB(3)=ALAB(3)
      READ(5,3000)TITLE
      CALL DRAWP(NPTS,TIME2,ZZV1,ITB,RTB)
 3000 FORMAT(6A8)
      STOP
      END
       SUBROUTINE RD(IUN,IO,IRS,IREC,IRQ)
C
C         THIS PROCEDURE FURNISHED BY DR. TIM STANTON,
C         DEPARTMENT OF OCEANOGRAPHY.
C
C                 READ DATA FROM IUN, ALLIGN , CHECK & RETURN
C
C        IUN=TAPE NUMBER, EG 20
C        IO=INTEGER*2 ARRAY, 16 LONG,(VALUES 0-4095, SUBTRACT 2048)*5
C              /2028.  GIVES VOLTAGE
C        IRS= NUMBER OF RESINCS ALLOWED (ERRORS)
C        IREC= COUNTER OF RECORDS (FRAMES OF DATA)
C            BLOCK 512 BITS,   32 BITS = RECORD
C            800 BPI TAPE UNLABLED
C        IRQ= NUMBER OF ACTUAL RESINCS (ERRORS)
C
C
       INTEGER * 2 IO(16),IP(16)
       DATA IRR /0/
       IF (IREC.EQ.0) IS=0
```

```
      IER=0                                                             VOLO1450
 20   FORMAT (16A2)                                                     VOLO1460
      IF (IS.NE.0) GO TC 50                                             VOLO1470
      READ (IUN,20,END=900) IP                                          VOLO1480
      IREC=IREC+1                                                       VOLO1490
 40   IS=IS+1                                                           VOLO1500
      IF (IS.LT.17) GO TO 50                                            VOLO1510
      READ (IUN,20,END=900) IP                                          VOLO1520
     IS=1                                                               VOLO1530
     IREC=IREC+1                                                        VOLO1540
 50  ICH=IMASK(IF(IS),3,0)+1                                            VOLO1550
C     WRITE (6,55) ICH,IS,IUN,IREC                                      VOLO1560
 55   FORMAT ('  RESYNCING ICH,IS,IUN,IREC ',4I8)                       VOLO1570
C                                                                       VOLO1580
     IF (ICF.NE.1) GO TO 40                                             VOLO1590
     DC 100 I=1,16                                                      VOLO1600
      IO(I)=ISHIFT(IP(IS),4)                                            VOLO1610
     ICH=IMASK(IP(IS),3,0)+1                                            VOLO1620
     IF (ICH.EQ.1) GO TO 80                                             VOLO163C
     IER=IER+1                                                          VOLO1640
     WRITE (6,70)  IUN,IREC ,I,ICH,IER                                  VOLO1650
 7C   FORMAT (' UNIT ',I3,' RECORD ',I6,'CHAN & DATA CH ',2I4,          VOLO1660
    $ 'ERRORS ',I7)                                                     VOLO1670
 80   IS=IS+1                                                           VOLO1680
      IF (IS.LT.17) GO TO 100                                           VOLO1690
      READ (IUN,20,END=9CC) IP                                          VOLO1700
      IS=1                                                              VOLO1710
      IREC=IREC+1                                                       VOLO1720
 100  CONTINUE                                                          VOLO1730
C                                                                       VOLO1740
      IF (IER.EC.0) GO TO 150                                           VOLO1750
      IRR=IRR+1                                                         VOLO1760
      IF (IRR.LT.IRS) GC TO 120                                         VOLO1770
      WRITE (6,110)                                                     VOLO1780
 110  FORMAT ('1 STCPPED IN SUB RD BECAUSE OF IRR.GT.',I6,' AT L11C')   VOLO1790
      IRQ=IRR                                                           VOLO1800
      STOP                                                              VOLO1810
 120  CONTINUE                                                          VOLO1820
      WRITE (6,130) IREC,IRR                                            VOLO1830
 130  FORMAT (' RESYNC AT FRAME ',I6,' WITH TOTAL ERRORS ',I7)          VOLO1840
      IER=0                                                             VOLO1850
      IRQ=IRR                                                           VOLO1860
      GO TO 50                                                          VOLO1870
 150  CONTINUE                                                          VOLO1880
      RETURN                                                            VOLO1890
 900  WRITE (6,910) IUN,IREC                                            VOLO1900
 910  FORMAT ('1   END OF UNIT ',I3,' AT REC ',I7)                      VOLO1910
      STOP                                                              VOLO1920
```

```
      END                                                               VOL01930
                                                                        VOL01940
      FUNCTION  ISHIFT (IN,NPLC)                                        VOL01950
C              RETURNS SHIFTED VALUE OF I*2 WORD IN                     VOL01960
C              -VE LEFT,+VE RIGHT SHIFT                                 VOL01970
C                                                                       VOL01980
      INTEGER * 2 IN                                                    VOL01990
      IP=IN                                                             VOL02000
      IF (IP.LT.0) IP=IP+65536                                          VOL02010
      IF (NPLC.LT.0) GO TO 30                                           VOL02020
      ISHIFT=IP/(2**IABS(NPLC))                                         VOL02030
      RETURN                                                            VOL02040
 30   ISHIFT=IP*(2**IABS(NPLC))                                         VOL02050
      IF (ISHIFT.GT.65535) ISHIFT=MOD(ISHIFT,65536)                     VOL02060
      RETURN                                                            VOL02070
      END                                                               VOL02080
      FUNCTION  IMASK (IN,IBL,IBR)                                      VOL02090
C              MASK I*2 WORD IN OUTSIDE BITS IBL & IBR                  VOL02100
C                                                                       VOL02110
      INTEGER * 2 IN,IO                                                 VOL02120
      IO=IN                                                             VOL02130
      IF (IBR.EQ.0) GO TO 50                                            VOL02140
      IT=ISHIFT(IN,IBR)                                                 VOL02150
      IO=IT                                                             VOL02160
 50   IP=ISHIFT(IO,IBL-15-IBR)                                          VOL02170
      IO=IP                                                             VOL02180
      IMASK=ISHIFT(IO,15-IBL)                                           VOL02190
      RETURN                                                            VOL02200
      END                                                               VOL02210
/*                                                                      VOL02220
//GO.SYSIN DD *                                                         VOL02230
CHEW'S RIDGE    ,  4 AUG 83, 1802-1819 LOCAL                            VOL02240
X COIL AMP IN VOLTS                                                     VOL02250
CHEW'S RIDGE    ,  4 AUG 83, 1802-1819 LOCAL                            VOL02260
Y COIL AMP IN VOLTS                                                     VOL02270
CHEW'S RIDGE    ,  4 AUG 83, 1802-1819 LOCAL                            VOL02280
Z COIL AMP IN VOLTS                                                     VOL02290
CHEW'S RIDGE    ,  4 AUG 83, 1802-1819 LOCAL                            VOL02300
X COIL AMP IN VOLTS                                                     VOL02310
CHEW'S RIDGE    ,  4 AUG 83, 1802-1819 LOCAL                            VOL02320
Y COIL AMP IN VOLTS                                                     VOL02330
CHEW'S RIDGE    ,  4 AUG 83, 1802-1819 LOCAL                            VOL02340
Z COIL AMP IN VOLTS                                                     VOL02350
/*                                                                      VOL02360
//GO.FT20F001 DD UNIT=3400-4,VOL=SER=CRDT3A,DISP=(OLD,KEEP),            VOL02370
//             LABEL=(1,NL,,IN),                                        VOL02380
//             DCB=(RECFM=FB,LRECL=32,BLKSIZE=512,DEN=2)                VOL02390
//GO.SYSDUMP DD SYSOUT=A                                                VOL02400
```

```
/*                                                                                                                 VOLO2410
//                                                                                                                 VOLO2420
```

APPENDIX D

VODIG COMPUTER PROGRAM

```
//CHFI23S JOB (2992,0165),'ANTHONY    SMC 2123',CLASS=G                 VODO0010
//*MAIN ORG=NPGVM1.2992P,LINES=(75)                                      VODO0020
//*FORMAT PR,DDNAME=PLOT.SYSVECTR,DEST=LOCAL                             VODO0030
// EXEC FRTXCLGP,PARM.LKED='LIST,MAP,XREF',REGION.GO=2048K                VODO0040
//FORT.SYSIN DD *                                                        VODO0050
C        THIS PROGRAM READS IN DATA FROM DIGITAL TAPES USING THE         VODO0060
C    SUBROUTINE RD, NORMALIZES THE DATA BETWEEN -5 AND +5 VOLTS, APPLIESVODO0070
C    A DIGITAL BANDPASS FILTER BETWEEN .04 AND .6 HZ DEVELOPED BY MIKE   VODO0080
C    HLETE AND THEN PUTS THE DATA THROUGH A 144 POINT DOUBLE RUNNING     VODO0090
C    AVERAGE SMOOTHING ROUTINE.                                          VODO0100
C                                                                        VODO0110
      INTEGER*2 IN(16)                                                   VODO0120
C       ARRAY 'IN' IS USED IN READING DATA FROM TAPE                     VODO0130
      REAL*8 XX(8196),YY(8196),ZZ(8196),XXS(8196),YYS(8196),ZZS(8196)    VODO0140
      REAL*8 FIX(18),FOX(18),FIY(18),FOY(18),FIZ(18),FOZ(18)             VODO0150
C       THE ABOVE REAL*8 ARRAYS ARE USED TO ORDER INPUT DATA AND         VODO0160
C       INITIALLY REPRESENT VOLTAGE - TIME SERIES INFORMATION.           VODO0170
      DIMENSION ZZX1(65568),ZZY1(65568),ZZV1(65568)                      VODO0180
      DIMENSION TIME2(65568)                                             VODO0190
      DATA FIX,FIY/36*0./                                                VODO0200
      DATA FIZ/18*0./                                                    VODO0210
      INTEGER K,C,I5,I4                                                  VODO0220
      REAL SUMX,SUMY,SUMZ,SUMT,AVE1,AVE2,AVE3,AVE4                       VODO0230
      INTEGER*4 ITB(12)/12*0/                                            VODO0240
      REAL*4    RTB(28)/28*0.0/                                          VODO0250
      REAL ALAB(4)/'CH-X','CH-Y','CH-Z','TOT'/                           VODO0260
      REAL*8 TITLE(12)                                                   VODO0270
      EQUIVALENCE(TITLE(1),RTB(5))                                       VODO0280
C       ARRAYS 'ITB','RTB','ALAB',AND 'TITLE' ARE USED IN GENERATING     VODO0290
C       THE VERTSATEC PLOTTER OUTPUT.                                    VODO0300
      DATA XX,YY/16392*0./                                               VODO0310
      DATA ZZ/8196*0./                                                   VODO0320
      K=0                                                                VODO0330
      I5=5                                                               VODO0340
      I6=1                                                               VODO0350
C   THE FOLLOWING LOOP ADVANCES THE DIGITAL TAPE BY ISEC SECONDS.        VODO0360
C                                                                        VODO0370
      ISEC=1940                                                          VODO0380
      ITL=ISEC*64                                                        VODO0390
      DO 55 JJ=1,ITL                                                     VODO0400
      CALL RD(20,IN,200,IREC,IRR)                                        VODO0410
   55 CONTINUE                                                           VODO0420
      IFRAME=8196                                                        VODO0430
      NR=3                                                               VODO0440
      FNR=FLOAT(NR)                                                      VODO0450
      DO 70 L1=1,NR                                                      VODO0460
C       THE DO LOOP ENDING WITH STATEMENT 70 ENABLES THE PROGRAM TO      VODO0470
C       PROCESS A LARGE AMOUNT OF DATA BY REPEATING THE PROCESS IN       VODO0480
```

```
C        BLOCKS.                                                        VODO0490
C        'NR' REPRESENTS THE NUMBER OF DATA SEQUENCES.                   VODO0500
C        1 SEQUENCE CURRENTLY EQUALS 8192 DATA POINTS FCR EACH CHANNEL   VODO0510
C        CR 128 SECCNDS OF DATA.                                         VODO0520
C                                                                        VODO0530
C         THE CO LCCP ENDING WITH 60 READS THE DATA FROM THE PCM FRAME   VODO0540
C         STRIPS OLT THE SYNC CODE, AND SORTS OUT THE DATA BY CCIL       VODO0550
C         CHANNEL                                                        VODO0560
      DC 60 JJ=5,IFRAME                                                 VODO0570
      CALL RC(20,IN,100C,IREC,IRR)                                      VODO0580
   58 XX(JJ)=IN(2)                                                      VODO0590
      YY(JJ)=IN(3)                                                      VODO060C
      ZZ(JJ)=IN(4)                                                      VODO0610
   60 CCNTINUE                                                          VODO0620
      N=8196                                                            VODO0630
      FN=FLOAT(N)                                                       VODO0640
      DELTAT=1./64.                                                     VODO0650
C     NORMALIZE THE DATA BETWEEN +5 AND -5 VOLTS.  FOR LAMESA DATA,     VODO0660
C     SUBTRACT 1.36, 1.0 AND 1.0 FROM XX, YY AND ZZ RESPECTIVELY, TC    VODO0670
C     REMOVE DC CCMPONENT.                                              VODO0680
      DO 20 J=5,N                                                       VODO0690
      XX(J)=((XX(J)-2048.)*5./2048.)                                    VODO0700
      YY(J)=((YY(J)-2048.)*5./2048.)                                    VODO0710
      ZZ(J)=((ZZ(J)-2048.)*5./2048.)                                    VODO0720
C        'XX' IS THE X-COIL DATA, 'YY' IS THE Y-COIL DATA,              VODO0730
C        'ZZ' IS THE Z-COIL DATA                                        VODO0740
C        NORTH-SOLTH COMPONENT (XX) AND THE VERTICAL CCMPCNENT (ZZ)     VODO0750
   2C CCNTINUE                                                          VODO0760
      DC 91 I3=5,8196                                                   VODO0770
      ZZX1(I5)=XX(I3)                                                   VODO0780
      ZZY1(I5)=YY(I3)                                                   VODO0790
      ZZV1(I5)=ZZ(I3)                                                   VODO0800
      I5=I5+1                                                           VODO0810
   91 CCNTINLE                                                          VODO0820
   7C CCNTINUE                                                          VODO0830
C     DCUBLE RUNNING POINT AVERAGE                                      VODO0840
      DC 73 L2=1,2                                                      VODO0850
      Q=0                                                               VODO0860
      DC 74 IS=5,65423                                                  VODO0870
      SLMX=0.0                                                          VODO0880
      SUMY=0.0                                                          VODO0890
      SLMZ=0.0                                                          VODO0900
      DO 75 J=5,149                                                     VODO0910
      SUMX=ZZX1(C+J)+SUMX                                               VODO0920
      SLMY=ZZY1(C+J)+SUMY                                               VODO0930
      SUMZ=ZZV1(C+J)+SUMZ                                               VODO0940
   75 CCNTINUE                                                          VODO0950
      ZZX1(IS)=SLMX/144.                                                VODO0960
```

```
      ZZY1(IS)=SLMY/144.                                               VODO0970
      ZZV1(IS)=SLMZ/144.                                               VODO0980
      Q=Q+1                                                            VCDO0990
   74 CCNTINUE                                                         VODO1000
   73 CCNTINUE                                                         VODO1010
C     APPLY CIGITAL FILTER TO DATA BLOCK                               VODO1020
      K2=5                                                             VODO1030
      DC 92 M1=1,NR                                                    VODO1040
      DC 100 K1=5,8196                                                 VODO1050
      XX(K1)=ZZX1(K2)                                                  VODO1060
      YY(K1)=ZZY1(K2)                                                  VODO1070
      ZZ(K1)=ZZV1(K2)                                                  VODO1080
      K2=K2+1                                                          VODO1090
  100 CCNTINUE                                                         VCDO1100
      CALL  DIGFIL(XX,FIX,XXS,FOX)                                     VODO1110
      CALL  DIGFIL(YY,FIY,YYS,FOY)                                     VODO1120
      CALL  DIGFIL(ZZ,FIZ,ZZS,FOZ)                                     VODO1130
      DC 21  L=1,18                                                    VODO1140
      FIX(L)=FOX(L)                                                    VODO1150
      FIY(L)=FOY(L)                                                    VODO1160
      FIZ(L)=FOZ(L)                                                    VODO1170
   21 CCNTINUE                                                         VODO1180
      I4=1                                                             VODO1190
      DC 90  I3=5,8196                                                 VODO1200
      ZZX1(I6)=XXS(I3)                                                 VODO1210
      ZZY1(I6)=YYS(I3)                                                 VODO1220
      ZZV1(I6)=ZZS(I3)                                                 VODO1230
      TIME2(I6)=(CELTAT*FLCAT(I4))+(128.0*FLOAT(K))                    VODO1240
      I4=I4+1                                                          VODO1250
      I6=I6+1                                                          VCDO1260
   90 CCNTINUE                                                         VODO1270
      K=K+1                                                            VODO1280
   92 CCNTINUE                                                         VODO1290
      NL=8192*NR-1280                                                  VODO1300
      DC 98  I7=1,NL                                                   VODO1310
      ZZX1(I7)=ZZX1(I7+1280)                                           VCDO1320
      ZZY1(I7)=ZZY1(I7+1280)                                           VODO1330
      ZZV1(I7)=ZZV1(I7+1280)                                           VODO1340
   98 CCNTINUE                                                         VODO1350
C                                                                      VODO1360
C    VERSATEC PLCT OF V - TIME SERIES VOLTAGE  SMCCTHEC                VODO1370
C                                                                      VODO1380
      NPTS=380./CELTAT +1.                                             VODO1390
C        'NPTS' DETERMINES NUMBER OF POINTS NECESSARY IN CRDER FCR     VODO1400
C         THE 0 TC NPTS  SECS RANGE TO BE PLOTTED.                     VODO1410
C       FOR THE FCLLOWING 'ITB' AND 'RTB' VALUES REVIEW THE WRITE-UP   VODO1420
C       FOR THE SLBROUTINE PROCEDURE 'DRAWP'.                          VODO1430
      ITB(3)=20                                                        VODO1440
```

```
      ITB(4)=8                                                          VODO1450
      ITB(7)=1                                                          VODO1460
      ITB(12)=0                                                         VODO1470
      RTB(1)=0.0                                                        VODO1480
      RTB(2)=0.0                                                        VODO1490
      RTB(3)=ALAB(1)                                                    VODO1500
      READ(5,3000)TITLE                                                 VODO1510
      CALL  DRAWP(NPTS,TIME2,ZZX1,ITB,RTB)                              VODO1520
      RTB(3)=ALAB(2)                                                    VODO1530
      READ(5,3000)TITLE                                                 VODO1540
      CALL  DRAWP(NPTS,TIME2,ZZY1,ITB,RTB)                              VODO1550
      RTB(3)=ALAB(3)                                                    VODO1560
      READ(5,3000)TITLE                                                 VODO1570
      CALL  DRAWP(NPTS,TIME2,ZZV1,ITB,RTB)                              VODO1580
      ITB(3)=7                                                          VODO1590
      ITB(4)=5                                                          VODO1600
      ITB(12)=0                                                         VODO1610
      RTB(3)=ALAB(1)                                                    VODO1620
      READ(5,3000)TITLE                                                 VODO1630
      CALL  DRAWP(NPTS,TIME2,ZZX1,ITB,RTB)                              VODO1640
      RTB(3)=ALAB(2)                                                    VODO1650
      READ(5,3000)TITLE                                                 VODO1660
      CALL  DRAWP(NPTS,TIME2,ZZY1,ITB,RTB)                              VODO1670
      RTB(3)=ALAB(3)                                                    VODO1680
      READ(5,3000)TITLE                                                 VODO1690
      CALL  DRAWP(NPTS,TIME2,ZZV1,ITB,RTB)                              VODO1700
 3000 FORMAT(6A8)                                                       VODO1710
      STOP                                                              VODO1720
      END                                                               VODO1730
       SUBROUTINE RD(IUN,IO,IRS,IREC,IRQ)                               VODO1740
C                                                                       VODO1750
C         THIS PROCEDURE FURNISHED BY DR. TIM STANTON,                  VODO1760
C         DEPARTMENT OF OCEANOGRAPHY.                                   VODO1770
C                                                                       VODO1780
C               READ DATA FROM IUN, ALLIGN , CHECK & RETURN             VODO1790
C                                                                       VODO1800
C        IUN=TAPE NUMBER, EG 20                                         VODO1810
C        IO=INTEGER*2 ARRAY, 16 LONG,(VALUES 0-4095, SUBTRACT 2048)*5   VODO1820
C              /2028.  GIVES VOLTAGE                                    VODO1830
C        IRS= NUMBER OF RESINCS ALLOWED (ERRORS)                        VODO1840
C        IREC= COUNTER OF RECORDS (FRAMES OF DATA)                      VODO1850
C            BLOCK 512 BITS,   32 BITS = RECORD                         VODO1860
C            800  BPI TAPE UNLABLED                                     VODO1870
C        IRQ= NUMBER OF ACTUAL RESINCS (ERRORS)                         VODO1880
C                                                                       VODO1890
C                                                                       VODO1900
       INTEGER * 2 IO(16),IP(16)                                        VODO1910
       DATA IRR /0/                                                     VODO1920
```

```
      IF (IREC.EC.0) IS=0                                                VODO1930
      IER=0                                                              VODO1940
   20 FORMAT (16A2)                                                      VODO1950
      IF (IS.NE.0) GO TC 50                                              VODO1960
      READ (IUN,20,END=90C) IP                                           VODO1970
      IREC= IREC+1                                                       VODO1980
   40 IS=IS+1                                                            VODO1990
      IF (IS.LT.17) GO TO 50                                             VODO2000
      READ (IUN,20,END=9C0) IP                                           VODO2010
     IS=1                                                                VODO2020
     IREC= IREC+1                                                        VODO2030
   50 ICH=IMASK(IP(IS),3,0)+1                                            VODO2040
C     WRITE (6,55) ICH,IS,IUN,IREC                                       VODO2050
C  55 FORMAT ('  RESYNCING ICH,IS,IUN,IREC ',4I8)                        VODO2060
C                                                                        VODO2070
     IF (ICH.NE.1) GO TO 40                                              VODO2080
     DC 100 I=1,16                                                       VODO2090
      IO(I)=ISHIFT(IP(IS),4)                                             VODO2100
     ICH=IMASK(IP(IS),3,0)+1                                             VODO2110
     IF (ICH.EQ.1) GO TO 80                                              VODO2120
     IER=IER+1                                                           VODO2130
     WRITE (6,7C)  IUN,IREC ,I,ICH,IER                                   VODO2140
   7C FORMAT (' UNIT ',I3,' RECORD ',I6,'CHAN & DATA CH ',2I4,           VODO2150
    $ 'ERRORS ',I7)                                                      VODO2160
   80 IS= IS+1                                                           VODO2170
      IF (IS.LT.17) GO TC 100                                            VODO2180
      READ (IUN,20,END=9C0) IP                                           VODO2190
      IS=1                                                               VODO2200
      IREC=IREC+1                                                        VODO2210
  100 CONTINUE                                                           VODO2220
C                                                                        VODO2230
      IF (IER.EC.0) GO TO 150                                            VODO2240
      IRR=IRR+1                                                          VODO2250
      IF (IRR.LT.IRS) GO TO 120                                          VODO2260
      WRITE (6,110)                                                      VODO2270
  110 FORMAT ('1 STCPPED IN SUB RD BECAUSE OF IRR.GT.',I6,' AT L110')    VODO2280
      IRQ=IRR                                                            VODO2290
      STOP                                                               VODO2300
  120 CONTINUE                                                           VODO2310
      WRITE (6,130) IREC,IRR                                             VODO2320
  130 FORMAT (' RESYNC AT FRAME ',I6,' WITH TOTAL ERRORS ',I7)           VODO2330
      IER=0                                                              VODO2340
      IRQ=IRR                                                            VODO2350
      GO TO 50                                                           VODO2360
  150 CONTINUE                                                           VODO2370
      RETURN                                                             VODO2380
  900 WRITE (6,910) IUN,IREC                                             VODO2390
  910 FORMAT ('1   END OF UNIT ',I3,' AT REC ',I7)                       VODO2400
```

```
      STOP                                                              VODO2410
      END                                                               VODO2420
C                                                                       VODO2430
      SUBROUTINE DIGFIL(INFLD,FILE,SIG,FOLE)                            VODO2440
C      THE ABOVE REAL*4 ARRAYS ARE USED TO ORDER  INPUT DATA AND        VODO2450
C      INITIALLY REPRESENT VOLTAGE - TIME SERIES  INFORMATION.          VODO2460
      REAL*8 INFLD(8196),OUTFLD(8196),SIG(8196)                         VODO2470
      REAL*8 YO(8196),YPO(8196),FILE(18),FOLE(18)                       VODO2480
      REAL*8 XI(8196),XII(8196),XIII(8196),XIV(8196),XV(8196)           VODO2490
      DATA XI,XII/16392*0./                                             VODO2500
      DATA XIII,XIV/16392*0./                                           VODO2510
      DATA XV,YO/16392*0./                                              VODO2520
      DATA YPO/8196*0./                                                 VODO2530
      DATA OUTFLD/8196*0./                                              VODO2540
      INTEGER K9                                                        VODO2550
C                                                                       VODO2560
C     THE COMPLEX*8 ARRAYS ARE USED TO ORDER INPUT DATA AND REPRESENT   VODO2570
C     VOLTAGE-TIME SERIES INFORMATION.                                  VODO2580
C                                                                       VODO2590
      REAL*8 T,AFHP1,AFHP2,BFHP0,BFHP1,BFHP2,A,B,C,D,E,F,A1             VODO2600
      REAL*8 B1,C1,D1,E1,F1,G1,H1,I1,J1,K1,L1                           VODO2610
      REAL*8 AA,BB,CC,DD,EE,FF,AA1,BB1,CC1,DD1,EE1,FF1,GG1,HH1,II1      VODO2620
      REAL*8 JJ1,KK1,LL1                                                VODO2630
      REAL*8 ASHP41,ASHP42,ASHP43,ASHP44,ASHP45,ASHP46,ASHP47           VODO2640
      REAL*8 ASLP61,ASLP62,ASLP63,ASLP64                                VODO2650
      REAL*8 BSLP60,BSLP61,BSLP62,BSLP63,BSLP64                         VODO2660
C                                                                       VODO2670
C     DEFINE AND COMPUTE ALL COEFFICIENTS                               VODO2680
C                                                                       VODO2690
      T=1./64.                                                          VODO2700
C                                                                       VODO2710
C     COEFFICIENTS FOR FIXED HIGH PASS FILTER                           VODO2720
C                                                                       VODO2730
      AFHP1=-((T**2/160.-2.)/(1.+T/8.+T**2/320.))                       VODO2740
      AFHP2=-((1.-T/8.+T**2/320.)/(1.+T/8.+T**2/320.))                  VODO2750
      BFHP0=(1./(1.+T/8.+T**2/320.))                                    VODO2760
      BFHP1=-(2./(1.+T/8.+T**2/320.))                                   VODO2770
      BFHP2=(1./(1.+T/8.+T**2/320.))                                    VODO2780
C                                                                       VODO2790
C     COEFFICIENTS FOR SELECTIVE HIGH PASS FILTER                       VODO2800
C     IN THIS CASE,   FREQ(LOWER)=0.04 HZ                               VODO2810
C                                                                       VODO2820
      A=12.52096/40.82834                                               VODO2830
      B=1./40.82834                                                     VODO2840
      C=11.00999/45.28317                                               VODO2850
      D=1./45.28317                                                     VODO2860
      E=7.41498/57.57668                                                VODO2870
      F=1./57.57668                                                     VODO2880
```

```
      A1=1.+A*T/2.+B*(T**2)/4.                                          VODO2890
      B1=-2.+B*(T**2/2.)                                                VODO2900
      C1=1.-A*T/2.+B*(T**2)/4.                                          VODO2910
      D1=1.+C*T/2.+D*(T**2)/4.                                          VODO2920
      E1=-2.+D*(T**2)/2.                                                VODO2930
      F1=1.-C*T/2.+D*(T**2)/4.                                          VODO2940
      G1=1.+E*T/2.+F*(T**2)/4.                                          VODO2950
      H1=-2.+F*(T**2)/2.                                                VODO2960
      I1=1.-E*T/2.+F*(T**2)/4.                                          VODO2970
C                                                                       VODO2980
C     CODE IS "ASHP41" MEANS "A1 COEFFICIENT FOR THE SELECTABLE HIGH    VODO2990
C     PASS FILTER WITH LOWER LIMIT 0.04 HZ"                             VODO3000
C                                                                       VODO3010
      ASHP41=1./(A1*D1*G1)                                              VODO3020
      ASHP42=-(C1/A1)                                                   VODO3030
      ASHP43=-(B1/A1)                                                   VODO3040
      ASHP44=-(E1/D1)                                                   VODO3050
      ASHP45=-(F1/D1)                                                   VODO3060
      ASHP46=-(H1/G1)                                                   VODO3070
      ASHP47=-(I1/G1)                                                   VODO3080
C                                                                       VODO3090
C     COEFFICIENTS FOR SELECTABLE LOW PASS FILTER WITH UPPER FREQ       VODO3100
C     OF 0.6 HZ                                                         VODO3110
C                                                                       VODO3120
      A=1./0.03492                                                      VODO3130
      B=0.35804/0.03492                                                 VODO3140
      C=1./0.03492                                                      VODO3150
      D=1./0.02779                                                      VODO3160
      E=0.20696/0.02779                                                 VODO3170
      F=1./0.02779                                                      VODO3180
      A1=A*(T**2)/4.                                                    VODO3190
      B1=2.*A1                                                          VODO3200
      C1=A1                                                             VODO3210
      D1=D*(T**2)/4.                                                    VODO3220
      E1=2.*D1                                                          VODO3230
      F1=D1                                                             VODO3240
      G1=(1.+B*T/2.+C*(T**2)/4.)                                        VODO3250
      H1=(-2.+C*(T**2)/2.)                                              VODO3260
      I1=(1.-B*T/2.+C*(T**2)/4.)                                        VODO3270
      J1=(1.+E*T/2.+F*(T**2)/4.)                                        VODO3280
      K1=(-2.+F*(T**2)/2.)                                              VODO3290
      L1=(1.-E*T/2.+F*(T**2)/4.)                                        VODO3300
      ASLP61=-(G1*K1+H1*J1)/(G1*J1)                                     VODO3310
      ASLP62=-(G1*L1+H1*K1+I1*J1)/(G1*J1)                               VODO3320
      ASLP63=-(H1*L1+I1*K1)/(G1*J1)                                     VODO3330
      ASLP64=-(I1*L1)/(G1*J1)                                           VODO3340
      BSLP60=(A1*C1)/(G1*J1)                                            VODO3350
      BSLP61=(A1*E1+B1*D1)/(G1*J1)                                      VODO3360
```

```
      BSLP62=(A1*F1+B1*E1+C1*D1)/(G1*J1)
      BSLP63=(B1*F1+C1*E1)/(G1*J1)
      BSLP64=(C1*F1)/(G1*J1)
C
C     SET TRANSFERED VALUES EQUAL TC INTIIAL ARRAY VALUES AND
C     APPLY DIGITAL FILTER TO ARRAY INFLD
      YC(4)=FILE(1)
      YO(3)=FILE(2)
      XI(4)=FILE(3)
      XI(3)=FILE(4)
      XIII(4)=FILE(5)
      XIII(3)=FILE(6)
      XV(4)=FILE(7)
      XV(3)=FILE(8)
      YPO(4)=FILE(9)
      YPO(3)=FILE(10)
      YPO(2)=FILE(11)
      YPO(1)=FILE(12)
      CUTFLD(4)=FILE(13)
      CUTFLD(3)=FILE(14)
      CLTFLD(2)=FILE(15)
      OLTFLD(1)=FILE(16)
      INFLD(4)=FILE(17)
      INFLD(3)=FILE(18)
      N=8196
      DC 92 I=5,N
      I1=I-1
      I2=I-2
      I3=I-3
      I4=I-4
      YC(I)=BFHPC*INFLD(I)+BFHP1*INFLD(I1)+BFHP2*INFLC(I2)+AFHP1*YO(I1)
     $+AFHP2*YO(I2)
      XI(I)=ASHP41*YO(I)+ASHP42*XI(I2)+ASHP43*XI(I1)
      XII(I)=XI(I)+XI(I2)-2.*XI(I1)
      XIII(I)=XII(I)+ASHP44*XIII(I1)+ASHP45*XIII(I2)
      XIV(I)=XIII(I)-2.*XIII(I1)+XIII(I2)
      XV(I)=XIV(I)+ASHP46*XV(I1)+ASHP47*XV(I2)
      YPO(I)=XV(I)+XV(I2)-2.*XV(I1)
      GP1=ASLP61*OUTFLD(I1)+ASLP62*OUTFLD(I2)+ASLP63*CUTFLD(I3)+ASLP64
     $*CUTFLC(I4)
      GP2=BSLP60*YPO(I)+BSLP61*YPO(I1)+BSLP62*YPC(I2)+BSLF63*YPO(I3)
     $+BSLP64*YPC(I4)
      CLTFLD(I)=GP1+GP2
      SIG(I)=OUTFLD(I)
C     WRITE(6,1) INFLD(I),YO(I),XI(I),XII(I),XIII(I),XIV(I)
C   1 FCRMAT(' A',6G10.5)
C     WRITE(6,2) XV(I),YPO(I),GP1,GP2,OUTFLD(I),SIG(I)
C   2 FCRMAT(' B',6G10.5)
```

```
   92 CCNTINUE                                                          VODO3850
      FCLE(1)=YO(8196)                                                  VODO3860
      FCLE(2)=YO(E195)                                                  VODO3870
      FCLE(3)=XI(E196)                                                  VODO3880
      FCLE(4)=XI(8195)                                                  VODO3890
      FOLE(5)=XIII(8196)                                                VODO3900
      FCLE(6)=XIII(8195)                                                VODO3910
      FCLE(7)=XV(E196)                                                  VODO3920
      FCLE(8)=XV(E195)                                                  VODO3930
      FCLE(9)=YPC(8196)                                                 VODO3940
      FOLE(10)=YPC(8195)                                                VODO3950
      FCLE(11)=YFC(8194)                                                VODO3960
      FCLE(12)=YFC(8193)                                                VODO3970
      FCLE(13)=OLTFLD(8156)                                             VODO3980
      FCLE(14)=OLTFLD(8195)                                             VODO3990
      FCLE(15)=OLTFLD(8154)                                             VODO4000
      FCLE(16)=OLTFLD(8193)                                             VODO4010
      FCLE(17)=INFLD(8196)                                              VODO4020
      FCLE(18)=INFLD(8155)                                              VODO4030
      RETURN                                                            VODO4040
      END                                                               VODO4050
       FUNCTION  ISHIFT (IN,NPLC)                                       VODO4060
C                RETURNS SHIFTED VALUE OF I*2 WORD IN                   VODO4070
C                -VE LEFT,+VE RIGHT SHIFT                               VODO4080
C                                                                       VODO4090
       INTEGER * 2 IN                                                   VODO4100
       IP=IN                                                            VODO4110
       IF (IP.LT.C) IP=IP+65536                                         VODO4120
       IF (NPLC.LT.0) GC TC 30                                          VODO4130
       ISHIFT=IP/(2**IABS(NPLC))                                        VODO4140
       RETURN                                                           VODO4150
 30    ISHIFT=IP*(2**IABS(NPLC))                                        VODO4160
       IF (ISHIFT.GT.65535) ISHIFT=MOD(ISHIFT,65536)                    VODO4170
       RETURN                                                           VODO4180
       END                                                              VODO4190
       FUNCTION  IMASK (IN,IBL,IBR)                                     VODO4200
C                MASK I*2 WCRD IN OUTSIDE BITS  IBL & IBR               VODO4210
C                                                                       VODO4220
       INTEGER * 2 IN,IO                                                VODO4230
       IO=IN                                                            VODO4240
       IF (IBR.EC.0) GO TC 50                                           VODO4250
       IT=ISHIFT(IN,IBR)                                                VODO4260
       IO=IT                                                            VODO4270
 50    IP=ISHIFT(IO,IBL-15-IBR)                                         VODO4280
       IO=IP                                                            VODO4290
       IMASK=ISHIFT(IO,15-IBL)                                          VODO4300
       RETURN                                                           VODO4310
       END                                                              VODO4320
```

```
/*                                                                      VOD04330
//GO.SYSIN DD *                                                         VOD04340
CHEW'S RIDGE    , 4 AUG 83, 1834-1840 LOCAL                             VOD04350
X COIL AMP IN VOLTS                                                     VOD04360
CHEW'S RIDGE    , 4 AUG 83, 1834-1840 LOCAL                             VOD04370
Y COIL AMP IN VOLTS                                                     VOD04380
CHEW'S RIDGE    , 4 AUG 83, 1834-1840 LOCAL                             VOD04390
Z COIL AMP IN VOLTS                                                     VOD04400
CHEW'S RIDGE    , 4 AUG 83, 1834-1840 LOCAL                             VOD04410
X COIL AMP IN VOLTS                                                     VOD04420
CHEW'S RIDGE    , 4 AUG 83, 1834-1840 LOCAL                             VOD04430
Y COIL AMP IN VOLTS                                                     VOD04440
CHEW'S RIDGE    , 4 AUG 83, 1834-1840 LOCAL                             VOD04450
Z COIL AMP IN VOLTS                                                     VOD04460
/*                                                                      VOD04470
//GO.FT20F001 DD UNIT=3400-4,VOL=SER=CRDT3A,DISP=(OLD,KEEP),            VOD04480
//             LABEL=(1,NL,,IN),                                        VOD04490
//             DCB=(RECFM=FB,LRECL=32,BLKSIZE=512,DEN=2)                VOD04500
//GO.SYSDUMP DD SYSOUT=A                                                VOD04510
/*                                                                      VOD04520
//                                                                      VOD04530
```

APPENDIX E

MASS STORAGE COMPUTER PROGRAM

```
//TAPEMS5 JOB (2992,0165),'ANTHONY SMC 2123',CLASS=G                 JOE00010
//*MAIN ORG=NPGVM1.2992P                                              JOE00020
// EXEC FORTXCLG                                                      JOE00030
//FORT.SYSIN DD *                                                     JOE00040
C                                                                     JOE00050
C     THIS PROGRAM READS DATA FROM A COMPUTER TAPE, NORMALIZES THE CATA  JOE00060
C     BETWEEN +5 AND -5 VOLTS AND STORES IT IN THE IBM 3033 MASS STORAGE JOE00070
C     SYSTEM FOR FUTURE RECALL. THE DATA IS READ ANC TRANSFERRED IN      JOE00080
C     BLCCKS OF 8192 SAMPLES (128 SECONDS OF DATA IN EACH BLOCK).        JOE00090
C            THE ARRAY 'IN' WILL BE USED TO                           JOE00100
C            RECEIVE THE DATA PASSED FROM                             JOE00110
C            THE SUBROUTINE 'RD' AND THEN                             JOE00120
C            TRANSFERRED TO THE APPROPRIATE                           JOE00130
C            XXX OR YYY OR ZZZ ARRAY.                                 JOE00140
      INTEGER*2 IN(16)                                                JOE00150
      CCMPLEX*8 XXX(8192),YYY(8192),ZZZ(8192)                         JOE00160
      CATA XXX,YYY/16384*(C.0,0.0)/                                   JOE00170
      DATA ZZZ/8192*(0.,0.)/                                          JOE00180
C            THE FCLLOWING SECTION READS THE FIRST                    JOE00190
C            ISEC SECONDS OF DATA FROM THE TAPE                       JOE00200
C            AND DISCARDS THIS DATA.                                  JOE00210
C                                                                     JOE00220
      ISEC=200                                                        JOE00230
      ITL=ISEC*64                                                     JOE00240
      CO 55 JJ=1,ITL                                                  JOE00250
      CALL RC(20,IN,200,IREC,IRR)                                     JOE00260
   55 CCNTINUE                                                        JOE00270
      IFRAME=8192                                                     JOE00280
C      THE VARIABLE NR SPECIFIES THE NUMBER OF BLOCKS OF CATA TO BE   JOE00290
C      READ FROM THE TAPE AND STORED IN THE MSS.                      JOE00300
      NR=19                                                           JOE00310
      DC 70 L1=1,NR                                                   JOE00320
C                                                                     JOE00330
C            THE NEXT LOOP READS NR FRAMES OF DATA (EACH FRAME        JOE00340
C            128 SECS LONG AT 64 HZ SAMPLING RATE) USING THE          JOE00350
C            SUBROUTINE RD, PROVIDED BY DR. TIM STANTON OF THE        JOE00360
C            NAVAL POSTGRADUATE SCHOOL.                               JOE00370
C                                                                     JOE00380
      DO 60 JJ=1,IFRAME                                               JOE00390
      CALL RC(20,IN,1000,IREC,IRR)                                    JOE00400
      XXX(JJ)=IN(2)                                                   JOE00410
      YYY(JJ)=IN(3)                                                   JOE00420
      ZZZ(JJ)=IN(4)                                                   JOE00430
   60 CCNTINUE                                                        JOE00440
      N=8192                                                          JOE00450
      DO 20 J=1,N                                                     JOE00460
C                                                                     JOE00470
C            THE NEXT 4 STEPS CCNVERT THE                             JOE00480
```

```
C          DATA TO VOLTAGE BETWEEN +5 AND -5 VOLTS AND SETS THE         JOE00490
C          IMAGINARY PART OF THE COMPLEX NUMBER EQUAL TO ZERO.          JOE00500
C                                                                       JOE00510
      XXX(J)=((XXX(J)-2048.)*5./2048.)-1.36                             JOE00520
C     XXX(J)=REAL(XXX(J))                                               JOE00530
      YYY(J)=((YYY(J)-2048.)*5./2048.)-1.0                              JOE00540
C     YYY(J)=REAL(YYY(J))                                               JOE00550
      ZZZ(J)=((ZZZ(J)-2048.)*5./2048.)-1.0                              JOE00560
C     ZZZ(J)=REAL(ZZZ(J))                                               JOE00570
   20 CONTINUE                                                          JOE00580
C                                                                       JOE00590
C                                                                       JOE00600
C          THE NEXT WRITE STATEMENTS SEND                               JOE00610
C          THE CONVERTED DATA TO MSS                                    JOE00620
C          FOR FUTURE MANIPULATION AND RECALL.                          JOE00630
C                                                                       JOE00640
C                                                                       JOE00650
C                                                                       JOE00660
C                                                                       JOE00670
      WRITE(21) XXX                                                     JOE00680
C     WRITE(6,*) XXX(1),XXX(8192)                                       JOE00690
      WRITE(21) YYY                                                     JOE00700
C     WRITE(6,*) YYY(1),YYY(8192)                                       JOE00710
      WRITE(21) ZZZ                                                     JOE00720
C     WRITE(6,*) ZZZ(1),ZZZ(8192)                                       JOE00730
   70 CONTINUE                                                          JOE00740
      WRITE(6,71)                                                       JOE00750
   71 FORMAT(' FINISHED WRITING TO MASS STORAGE')                       JOE00760
      ENDFILE 21                                                        JOE00770
      STOP                                                              JOE00780
      END                                                               JOE00790
       SUBROUTINE RD(IUN,IO,IRS,IREC,IRQ)                               JOE00800
C                                                                       JOE00810
C         THIS PROCEDURE FURNISHED BY DR. TIM STANTON,                  JOE00820
C         DEPARTMENT OF OCEANOGRAPHY.                                   JOE00830
C                                                                       JOE00840
C              READ DATA FROM IUN, ALLIGN , CHECK & RETURN              JOE00850
C                                                                       JOE00860
C       IUN=TAPE NUMBER, EG 20                                          JOE00870
C       IO=INTEGER*2 ARRAY, 16 LONG,(VALUES 0-4095, SUBTRACT 2048)*5    JOE00880
C                /2028.   GIVES VOLTAGE                                 JOE00890
C       IRS= NUMBER OF RESINCS ALLOWED (ERRORS)                         JOE00900
C       IREC= COUNTER OF RECORDS (FRAMES OF DATA)                       JOE00910
C           BLOCK 512 BITS,   32 BITS = RECORD                          JOE00920
C           800 BPI TAPE UNLABLED                                       JOE00930
C       IRQ= NUMBER OF ACTUAL RESINCS (ERRORS)                          JOE00940
C                                                                       JOE00950
C                                                                       JOE00960
```

```
      INTEGER * 2 IO(16),IP(16)                                         JOE00970
      CATA IRR /C/                                                      JOE00980
      IF (IREC.EQ.0) IS=0                                               JOE00990
      IER=0                                                             JOE01000
 20   FORMAT (16A2)                                                     JOE01010
      IF (IS.NE.0) GO TO 50                                             JOE01020
      READ (IUN,20,END=900) IP                                          JOE01030
      IREC=IREC+1                                                       JOE01040
 40   IS=IS+1                                                           JOE01050
      IF (IS.LT.17) GO TC 50                                            JOE01060
      READ (IUN,20,END=9CC) IP                                          JOE01070
     IS=1                                                               JOE01080
     IREC=IREC+1                                                        JOE01090
 50  ICH=IMASK(IP(IS),3,0)+1                                            JOE01100
C     WRITE (6,55) ICH,IS,IUN,IREC                                      JOE01110
 55   FORMAT ('  RESYNCING ICH,IS,IUN,IREC ',4I8)                       JOE01120
C                                                                       JOE01130
     IF (ICH.NE.1) GO TO 40                                             JOE01140
     DO 100 I=1,16                                                      JOE01150
      IO(I)=ISHIFT(IP(IS),4)                                            JOE01160
     ICH=IMASK(IP(IS),3,0)+1                                            JOE01170
     IF (ICH.EQ.I) GO TO 80                                             JOE01180
     IER=IER+1                                                          JOE01190
     WRITE (6,7C)  IUN,IREC ,I,ICH,IER                                  JOE01200
 70   FORMAT (' UNIT ',I3,' RECORD ',I6,'CHAN & DATA CH ',2I4,          JOE01210
     $ 'ERRORS ',I7)                                                    JOE01220
 80   IS=IS+1                                                           JOE01230
      IF (IS.LT.17) GO TO 100                                           JOE01240
      READ (IUN,20,END=900) IP                                          JOE01250
      IS=1                                                              JOE01260
      IREC=IREC+1                                                       JOE01270
 100  CONTINUE                                                          JOE01280
C                                                                       JOE01290
      IF (IER.EC.0) GO TO 150                                           JOE01300
      IRR=IRR+1                                                         JOE01310
      IF (IRR.LT.IRS) GO TO 120                                         JOE01320
      WRITE (6,110)                                                     JOE01330
 110  FORMAT ('1 STOPPED IN SUB RD BECAUSE OF IRR.GT.',I6,' AT L110')   JOE01340
      IRQ=IRR                                                           JOE01350
      STOP                                                              JOE01360
 120  CONTINUE                                                          JOE01370
      WRITE (6,130) IREC,IRR                                            JOE01380
 130  FORMAT (' RESYNC AT FRAME ',I6,' WITH TCTAL ERRORS ',I7)          JOE01390
      IER=0                                                             JOE01400
      IRQ=IRR                                                           JOE01410
      GO TO 50                                                          JOE01420
 150  CCNTINUE                                                          JOE01430
      RETURN                                                            JOE01440
```

```
 900    WRITE (6,910) IUN,IREC
 910    FORMAT ('1   END OF UNIT ',I3,' AT REC ',I7)
        STOP
        END

        FUNCTION ISHIFT (IN,NPLC)
C                RETURNS SHIFTED VALUE OF I*2 WCRD IN
C                -VE LEFT,+VE RIGHT SHIFT
C
        INTEGER * 2 IN
        IP=IN
        IF (IP.LT.C) IP=IP+65536
        IF (NPLC.LT.0) GC TC 30
        ISHIFT=IP/(2**IABS(NPLC))
        RETURN
 30     ISHIFT=IP*(2**IABS(NPLC))
        IF (ISHIFT.GT.65535) ISHIFT=MOD(ISHIFT,65536)
        RETURN
        END
        FUNCTION IMASK (IN,IBL,IBR)
C                MASK I*2 WORD IN OUTSIDE BITS IBL & IBR
C
        INTEGER * 2 IN,IC
        IO=IN
        IF (IBR.EC.0) GO TC 50
        IT=ISHIFT(IN,IBR )
        IO=IT
 50     IP=ISHIFT(IO,IBL-15-IBR)
        IO=IP
        IMASK=ISHIFT(IO,15-IBL)
        RETURN
        END
/*
//GO.FT21F001 DD UNIT=3330V,MSVGP=PUB4A,DISP=(NEW,CATLG),
//               DSN=MSS.S2992.LMDT3D,
//               DCE=(RECFM=VBS,BLKSIZE=4096,LRECL=4092),
//               SPACE=(CYL,(8,4))
//GC.FT20F001 DD UNIT=3400-4,VOL=SER=LMDT3,DISP=(OLC,PASS),
//               LABEL=(1,NL,,IN),
//               DCE=(RECFM=FB,LRECL=32,BLKSIZE=512,DEN=2)
//
```

APPENDIX F

MAGFLD COMPUTER PROGRAM

```
//LAMA2CB JOB (1029,0129),'STEVENS    SMC 2670 ',CLASS=G
//*MAIN ORG=NPGVM1.1029P,LINES=(65)
//*FORMAT PR,DDNAME=PLOT.SYSVECTR,DEST=LOCAL
// EXEC FRTXCLGP,PARM.LKED='LIST,MAP,XREF',REGION.GO=2048K
//FORT.SYSIN DD DSN=MSS.SYS3.NONIMSL.SOURCE(FOURT),DISP=SHR
//    DD *
      INTEGER*2 IN(16)
C       ARRAY 'IN' IS USED IN READING DATA FROM TAPE
      COMPLEX*8 XX(8192),YY(8192),ZZ(8192),TF(8192)
C       THE ABOVE COMPLEX*8 ARRAYS ARE USED TO ORDER INPUT DATA AND
C       INITIALLY REPRESENT VOLTAGE - TIME SERIES INFORMATION.
      DIMENSION TIME(8192),FREQ(8192),WORK(16384),FRQ2(8192)
      DIMENSION ZX1(8192),ZY1(8192),ZV1(8192),ZT1(8192)
      DIMENSION ZZX1(65536),ZZY1(65536),ZZV1(65536)
      DIMENSION ZZT1(65536),TIME2(65536)
C       THE 'Z' ARRAYS REPRESENT FREQUENCY DOMAIN (FF TRANSFORMED)
C       MAGNITUDE DATA AND ARE EVENTUALLY CONVERTED TO POWER SPECTRAL
C       DENSITY INFORMATION. ZX1,ZY1,ZV1,AND ZT1 REPRESENT MAGNITUDE
C       VALUES.
      INTEGER K,I4,I5,Q
      REAL SUMX,SUMY,SUMZ,SUMT,AVE1,AVE2,AVE3,AVE4
      REAL CONSTX,CONSTY,CONSTZ,CONSTT
      INTEGER*4 IIB(12)/12*0/
      REAL*4    RTB(28)/28*0.0/
      REAL ALAB(4)/'CH-X','CH-Y','CH-Z','TOT'/
      REAL*8 TITLE(12)
      EQUIVALENCE(TITLE(1),RTB(5))
C       ARRAYS 'ITE','RTB','ALAB',AND 'TITLE' ARE USED IN GENERATING
C       THE VERTSATEC PLOTTER OUTPUT.
      DATA XX,YY/16384*(0.,0.)/
      DATA ZZ,TF/16384*(0.,0.)/
      DATA ZX1,ZY1/16384*0./
      DATA ZV1,ZT1/16384*0./
      DATA TIME,FREQ/16384*0./
      K=0
      I4=1
      I5=1
      CONSTX=0.0
      CONSTY=0.0
      CONSTZ=0.0
      CONSTT=0.0
      SUMX=0.0
      SUMY=0.0
      SUMZ=0.0
      SUMT=0.0
      AVE1=0.0
      AVE2=0.0
      AVE3=0.0
```

```
      AVE4=0.0                                                          LFV00490
      DC 31 IN1=1,65536                                                 LFV00500
      ZZX1(IN1)=C.0                                                     LFV00510
      ZZY1(IN1)=0.0                                                     LFV00520
      ZZV1(IN1)=C.0                                                     LFV00530
      ZZT1(IN1)=0.0                                                     LFV00540
      TIME2(IN1)=C.0                                                    LFV00550
   31 CCNTINUE                                                          LFV00560
C       THE NEXT FIVE LINES SERVE AS A TIME DELAY IN STARTING THE       LFV00570
C       DATA ANALYSIS                                                   LFV00580
      ISEC=10                                                           LFV00590
      ITL=ISEC*64                                                       LFV00600
      DC 55 JJ=1,ITL                                                    LFV00610
      CALL RC(20,IN,200,IREC,IRR)                                       LFV00620
   55 CCNTINUE                                                          LFV00630
      IFRAME=8192                                                       LFV00640
      NR=8                                                              LFV00650
      FNR=FLCAT(NR)                                                     LFV00660
      CC 70 L1=1,NR                                                     LFV00670
C      THE DC LOCF ENDING WITH STATEMENT 70 ENABLES THE PROGRAM TO      LFV00680
C      PROCESS A LARGE AMOUNT OF DATA BY REPEATING THE PRCCESS IN       LFV00690
C      BLOCKS.                                                          LFV00700
C      'NR' REPRESENTS THE NUMBER OF DATA SEQUENCES TO BE AVERAGED.     LFV00710
C      1 SEQUENCE CURRENTLY EQUALS 8192 DATA PCINTS FCR EACH CHANNEL    LFV00720
C      CR 256 SECCNDS OF DATA.                                          LFV00730
C                                                                       LFV00740
C       THE CO LCCP ENDING WITH 60 READS THE DATA FROM THE PCM FRAME    LFV00750
C       STRIPS OLT THE SYNC CODE, AND SORTS OUT THE DATA BY COIL        LFV00760
C       CHANNEL                                                         LFV00770
      CC 60 JJ=1,IFRAME                                                 LFV00780
      CALL RC(20,IN,1000,IREC,IRR)                                      LFV00790
      XX(JJ)=IN(2)                                                      LFV00800
      YY(JJ)=IN(3)                                                      LFV00810
      ZZ(JJ)=IN(4)                                                      LFV00820
   6C CCNTINUE                                                          LFV00830
C       THE FOLLCWING SECTION GENERATES THE TIME AND FREQUENCY          LFV00840
C       ARRAYS AND NORMALIZES THE INPUT PCM DATA TC VCLTAGE FORM        LFV00850
C       IN PREPARATION FOR FAST FOURIER TRANSFORM TC THE FREQLENCY      LFV00860
C       DOMAIN.                                                         LFV00870
      N=8192                                                            LFV00880
      FN=FLOAT(N)                                                       LFV00890
      DELTAT=1./64.                                                     LFV00900
      DELTAF=1./(FN*DELTAT)                                             LFV00910
      CC 20 J=1,N                                                       LFV00920
      TIME(J)=DELTAT*FLCAT(J)                                           LFV00930
      FREQ(J)=DELTAF*FLCAT(J)                                           LFV00940
      XX(J)=((XX(J)-2048.)*5./2048.)-1.36                               LFV00950
      XX(J)=REAL(XX(J))                                                 LFV00960
```

```
      YY(J)=((YY(J)-2048.)*5./2048.)-1.0                                  LFV00970
      YY(J)=REAL(YY(J))                                                   LFV00980
      ZZ(J)=((ZZ(J)-2048.)*5./2048.)-1.0                                  LFV00990
      ZZ(J)=REAL(ZZ(J))                                                   LFV01000
C        'XX' IS THE X-CCIL CATA, 'YY' IS THE Y-CCIL CATA,                LFV01010
C        'ZZ' IS THE Z-COIL DATA, AND 'TF' IS THE PRCJECTICN OF THE       LFV01020
C        NORTH-SOUTH COMPCNENT (XX) AND THE VERTICAL CCMPONENT (ZZ)       LFV01030
C        ON THE TCTAL GECMAGNETIC FIELD VECTOR.                           LFV01040
   20 CCNTINUE                                                            LFV01050
      DC 21 J=1,N                                                         LFV01060
      FRQ2(J)=ALCG10(FREQ(J))                                             LFV01070
   21 CCNTINUE                                                            LFV01080
C        THE NEXT FOUR STATEMENTS PERFORM AN FFT CN THE INPUT             LFV01090
C        TIME SERIES DATA. SEE THE WRITEUP ON 'FCURT' FOR                 LFV01100
C        FURTHER INFORMATICN.                                             LFV01110
      CALL FCURT(XX,N,1,-1,0,WORK)                                        LFV01120
      CALL FOURT(YY,N,1,-1,0,WORK)                                        LFV01130
      CALL FCURT(ZZ,N,1,-1,0,WORK)                                        LFV01140
C       THE NEXT BLOCK OF STATEMENTS APPLY THE SYSTEM (VOLTAGE TO         LFV01150
C       B-FIELD) TRANSFER FUNCTION TO THE TRANSFORMED FREQUENCY           LFV01160
C       DOMAIN DATA.  THIS BLOCK ENDS AT STATEMENT 9.                     LFV01170
C       THE TRANSFER FUNCTICN CONVERTS VOLTS TO NANCTESLAS (GAMMAS).      LFV01180
C       ***WARNING*** THIS TRANSFER FUNCTIONS YIELDS AN INACCURATE        LFV01190
C       PHASE.  USE A DIFFERENT TRANSFER FUNCTION IF PHASE INFCRMATION    LFV01200
C       NEEDED.                                                           LFV01210
      DC 9 L=1,N                                                          LFV01220
      FRQ=FREQ(L)                                                         LFV01230
      IF(FRQ.LE.25.)GO TO 1                                               LFV01240
      XX(L)=XX(L)/28.                                                     LFV01250
      GO TO 8                                                             LFV01260
    1 IF(FRQ.LE.15.)GO TO 2                                               LFV01270
      XX(L)=XX(L)/(105.5-3.14*FRQ)                                        LFV01280
      YY(L)=YY(L)/(181.32-7.588*FRQ)                                      LFV01290
      ZZ(L)=ZZ(L)/(177.26-7.484*FRQ)                                      LFV01300
      GO TO 8                                                             LFV01310
    2 IF(FRQ.LE.10.)GO TO 3                                               LFV01320
      XX(L)=XX(L)/(5.958*FRQ-30.97)                                       LFV01330
      YY(L)=YY(L)/(7.166*FRQ-39.99)                                       LFV01340
      ZZ(L)=ZZ(L)/(6.49*FRQ-32.35)                                        LFV01350
      GC TO 8                                                             LFV01360
    3 IF(FRQ.LE.7.5)GO TO 4                                               LFV01370
      XX(L)=XX(L)/(3.492*FRQ-6.31)                                        LFV01380
      YY(L)=YY(L)/(4.252*FRQ-10.85)                                       LFV01390
      ZZ(L)=ZZ(L)/(4.044*FRQ-7.89)                                        LFV01400
      GC TO 8                                                             LFV01410
    4 IF(FRQ.LE.5.)GO TC 5                                                LFV01420
      XX(L)=XX(L)/(2.6311*FRQ+0.14667)                                    LFV01430
      YY(L)=YY(L)/(3.012*FRQ-1.55)                                        LFV01440
```

```
      ZZ(L)=ZZ(L)/(3.184*FRQ-1.44)
      GC TO 8
    5 IF(FRQ.LE.3.)GO TC 6
      XX(L)=XX(L)/(2.6311*FRQ+0.14667)
    7 YY(L)=YY(L)/(2.702*FRQ)
      ZZ(L)=ZZ(L)/(2.92*FRQ)
      GC TO 8
    6 XX(L)=XX(L)/(2.72*FRQ)
      GO TO 7
    8 CCNTINUE
      TF(L)=(XX(L)*.5 + ZZ(L)*.866)
    9 CCNTINUE
      CALL  FCURT(XX,N,1,1,1,WORK)
      CALL  FCURT(YY,N,1,1,1,WORK)
      CALL  FCURT(ZZ,N,1,1,1,WORK)
      CALL  FCURT(TF,N,1,1,1,WORK)
      DO 57  J=1,N
      XX(J)=XX(J)/FN
      YY(J)=YY(J)/FN
      ZZ(J)=ZZ(J)/FN
      TF(J)=TF(J)/FN
   57 CCNTINLE
      DC 56  I3=1,N
      ZX1(I3)=CABS(XX(I3))
      ZY1(I3)=CABS(YY(I3))
      ZV1(I3)=CABS(ZZ(I3))
      ZT1(I3)=CABS(TF(I3))
   56 CCNTINUE
C     THE NEXT  44 LINES  OF CODE CORRECT DATA BLOCK END JUMPS.
      IF(K.NE.0) GO TO 36
      DO 66  IS=8C48,8192
      SUMX=ZX1(IS)+SUMX
      SLMY=ZY1(IS)+SUMY
      SUMZ=ZV1(IS)+SUMZ
      SLMT=ZT1(IS)+SUMT
   66 CCNTINLE
      CCNSTX=SUMX/144.
      CCNSTY=SUMY/144.
      CCNSTZ=SUMZ/144.
      CCNSTT=SUMT/144.
      DC 67  IS=1,8192
      ZZX1(I4)=ZX1(IS)
      ZZY1(I4)=ZY1(IS)
      ZZV1(I4)=ZV1(IS)
      ZZT1(I4)=ZT1(IS)
      I4=I4+1
   67 CCNTINLE
      GC TO 37
```

```
   36 CONTINUE                                                          LFV01930
      SUMX=0.0                                                          LFV01940
      SUMY=0.0                                                          LFV01950
      SUMZ=0.0                                                          LFV01960
      SUMT=0.0                                                          LFV01970
      DO 68  IS=1,144                                                   LFV01980
      SUMX=ZX1(IS)+SUMX                                                 LFV01990
      SUMY=ZY1(IS)+SUMY                                                 LFV02000
      SUMZ=ZV1(IS)+SUMZ                                                 LFV02010
      SUMT=ZT1(IS)+SUMT                                                 LFV02020
   68 CONTINUE                                                          LFV02030
      AVE1=SUMX/144.                                                    LFV02040
      AVE2=SUMY/144.                                                    LFV02050
      AVE3=SUMZ/144.                                                    LFV02060
      AVE4=SUMT/144.                                                    LFV02070
      DO 69  IS=1,8192                                                  LFV02080
      ZZX1(I4)=ZX1(IS)+(CONSTX-AVE1)                                    LFV02090
      ZZY1(I4)=ZY1(IS)+(CONSTY-AVE2)                                    LFV02100
      ZZV1(I4)=ZV1(IS)+(CONSTZ-AVE3)                                    LFV02110
      ZZT1(I4)=ZT1(IS)+(CONSTT-AVE4)                                    LFV02120
      I4=I4+1                                                           LFV02130
   69 CONTINUE                                                          LFV02140
   37 CONTINUE                                                          LFV02150
      DO 91  I3=1,8192                                                  LFV02160
      TIME2(I5)=(DELTAT*FLOAT(I3))+(128.0*FLOAT(K))                     LFV02170
      I5=I5+1                                                           LFV02180
   91 CONTINUE                                                          LFV02190
      K=K+1                                                             LFV02200
   70 CONTINUE                                                          LFV02210
C     THE FOLLOWING LINES OF CODE PERFORMS A DOUBLE RUNNING POINT       LFV02220
C     AVERAGE ON THE DATA.                                              LFV02230
      DO 73 L2=1,2                                                      LFV02240
      Q=0                                                               LFV02250
      DO 74  IS=1,65318                                                 LFV02260
      SUMX=0.0                                                          LFV02270
      SUMY=0.0                                                          LFV02280
      SUMZ=0.0                                                          LFV02290
      SUMT=0.0                                                          LFV02300
      DO 75  J=1,144                                                    LFV02310
      SUMX=ZZX1(Q+J)+SUMX                                               LFV02320
      SUMY=ZZY1(Q+J)+SUMY                                               LFV02330
      SUMZ=ZZV1(Q+J)+SUMZ                                               LFV02340
      SUMT=ZZT1(Q+J)+SUMT                                               LFV02350
   75 CONTINUE                                                          LFV02360
      ZZX1(IS)=SUMX/144.                                                LFV02370
      ZZY1(IS)=SUMY/144.                                                LFV02380
      ZZV1(IS)=SUMZ/144.                                                LFV02390
      ZZT1(IS)=SUMT/144.                                                LFV02400
```

```
      Q=Q+1                                                             LFV02410
   74 CCNTINLE                                                          LFV02420
   73 CCNTINUE                                                          LFV02430
C                                                                       LFV02440
C    VERSATEC PLCT OF B - MAGNETIC FIELD (SMOOTHEC)                     LFV02450
C                                                                       LFV02460
      NPTS=1020/CELTAT +1.                                              LFV02470
C        'NPTS' DETERMINES NUMBER OF POINTS NECESSARY IN CRCER FOR      LFV02480
C         THE 0 TC 2041  SECS RANGE TO BE PLOTTED.                      LFV02490
C        FOR THE FCLLOWING 'ITB' AND 'RTB' VALUES REVIEW TFE WRITE-UP   LFV02500
C        FOR THE SLBROUTINE PROCEDURE 'DRAWP'.                          LFV02510
      ITB(3)=20                                                         LFV02520
      ITB(4)=8                                                          LFV02530
      ITB(7)=1                                                          LFV02540
      ITB(12)=0                                                         LFV02550
      RTB(1)=0.0                                                        LFV02560
      RTB(2)=0.0                                                        LFV02570
      RTB(3)=ALAE(1)                                                    LFV02580
      READ(5,300C)TITLE                                                 LFV02590
      CALL  DRAWP(NPTS,TIME2,ZZX1,ITB,RTB)                              LFV02600
      RTB(3)=ALAE(2)                                                    LFV02610
      READ(5,30CC)TITLE                                                 LFV02620
      CALL  DRAWP(NPTS,TIME2,ZZY1,ITB,RTB)                              LFV02630
      RTB(3)=ALAE(3)                                                    LFV02640
      READ(5,300C)TITLE                                                 LFV02650
      CALL  DRAWP(NPTS,TIME2,ZZV1,ITB,RTB)                              LFV02660
      ITB(12)=1                                                         LFV02670
      RTB(3)=ALAB(4)                                                    LFV02680
      READ(5,3000)TITLE                                                 LFV02690
      CALL  DRAWP(NPTS,TIME2,ZZT1,ITB,RTB)                              LFV02700
      ITB(3)=7                                                          LFV02710
      ITB(4)=5                                                          LFV02720
      ITB(12)=0                                                         LFV02730
      RTB(3)=ALAE(1)                                                    LFV02740
      READ(5,300C)TITLE                                                 LFV02750
      CALL  DRAWP(NPTS,TIME2,ZZX1,ITB,RTB)                              LFV02760
      RTB(3)=ALAE(2)                                                    LFV02770
      READ(5,300C)TITLE                                                 LFV02780
      CALL  DRAWP(NPTS,TIME2,ZZY1,ITB,RTB)                              LFV02790
      RTB(3)=ALAE(3)                                                    LFV02800
      READ(5,300C)TITLE                                                 LFV02810
      CALL  DRAWP(NPTS,TIME2,ZZV1,ITB,RTB)                              LFV02820
      ITB(12)=1                                                         LFV0283C
      RTB(3)=ALAE(4)                                                    LFV02840
      READ(5,300C)TITLE                                                 LFV02850
      CALL  DRAWP(NPTS,TIME2,ZZT1,ITB,RTB)                              LFV02860
 3000 FORMAT(6A8)                                                       LFV02870
      STOP                                                              LFV02880
```

```
      END
       SUBROUTINE RD(IUN,IC,IRS,IREC,IRQ)
C
C         THIS PRCCEDURE FURNISHED BY DR. TIM STANTCN,
C         DEPARTMENT OF OCEANOGRAPHY.
C
C              READ DATA FROM IUN, ALLIGN , CHECK & RETURN
C
C        IUN=TAPE NUMBER, EG 20
C        IO=INTEGER*2 ARRAY, 16 LONG,(VALUES 0-4095, SLBTRACT 2048)*5
C                /2028.  GIVES VOLTAGE
C        IRS= NUMBER OF RESINCS ALLOWED (ERRORS)
C        IREC= COLNTER OF RECORDS (FRAMES CF DATA)
C            BLOCK 512 BITS,   32 BITS = RECORD
C            800 BPI TAPE UNLABLED
C        IRQ= NUMEER OF ACTLAL RESINCS (ERRORS)
C
C
       INTEGER * 2 IO(16),IP(16)
       CATA IRR /C/
       IF (IREC.EQ.0) I S=0
       IER=0
 20    FORMAT (16A2)
       IF (IS.NE.C) GO TO 50
       READ (IUN,20,END=900) IP
       IREC=IREC+1
 40    IS=IS+1
       IF (IS.LT.17) GO TO 50
       READ (IUN,20,END=90C) IP
      IS=1
      IREC=IREC+1
 50   ICH=IMASK(IP(IS),3,0)+1
C      WRITE (6,55) ICH,IS,IUN,IREC
 55    FORMAT ('  RESYNCING ICH,IS,IUN,IREC ',4I8)
C
      IF (ICH.NE.1) GO TO 40
      DC 100 I=1,16
       IO(I)=ISHIFT(IP(IS),4)
      ICH=IMASK(IF(IS),3,0)+1
      IF (ICH.EQ.I) GO TO 80
      IER=IER+1
      WRITE (6,7C)  IUN,IREC ,I,ICH,IER
 70    FORMAT (' UNIT ',I3,' RECORD ',I6,'CHAN & DATA CH ',2I4,
     $ 'ERRORS ',I7)
 80    IS=IS+1
       IF (IS.LT.17) GO TC 100
       READ (IUN,20,END=900) IP
       IS=1
```

```
      IREC=IREC+1                                                       LFV03370
  100 CONTINUE                                                          LFV03380
C                                                                       LFV03390
      IF (IER.EC.0) GO TO 150                                           LFV03400
      IRR=IRR+1                                                         LFV03410
      IF (IRR.LT.IRS) GO TO 120                                         LFV03420
      WRITE (6,110)                                                     LFV03430
  110 FORMAT ('1 STOPPED IN SUB RD BECAUSE OF IRR.GT.',I6,' AT L110')   LFV03440
      IRQ=IRR                                                           LFV03450
      STOP                                                              LFV03460
  120 CONTINUE                                                          LFV03470
      WRITE (6,130) IREC,IRR                                            LFV03480
  130 FORMAT (' RESYNC AT FRAME ',I6,' WITH TOTAL ERRORS ',I7)          LFV03490
      IER=0                                                             LFV03500
      IRQ=IRR                                                           LFV03510
      GO TO 50                                                          LFV03520
  150 CONTINUE                                                          LFV03530
      RETURN                                                            LFV03540
  900 WRITE (6,910) IUN,IREC                                            LFV03550
  910 FORMAT ('1   END OF UNIT ',I3,' AT REC ',I7)                      LFV03560
      STOP                                                              LFV03570
      END                                                               LFV03580
      FUNCTION ISHIFT (IN,NPLC)                                         LFV03590
C              RETURNS SHIFTED VALUE OF I*2 WORC IN                     LFV03600
C              -VE LEFT,+VE RIGHT SHIFT                                 LFV03610
C                                                                       LFV03620
      INTEGER * 2 IN                                                    LFV03630
      IP=IN                                                             LFV03640
      IF (IP.LT.0) IP=IP+65536                                          LFV03650
      IF (NPLC.LT.0) GC TC 30                                           LFV03660
      ISHIFT=IP/(2**IABS(NPLC))                                         LFV03670
      RETURN                                                            LFV03680
   30 ISHIFT=IP*(2**IABS(NPLC))                                         LFV03690
      IF (ISHIFT.GT.65535) ISHIFT=MOD(ISHIFT,65536)                     LFV03700
      RETURN                                                            LFV03710
      END                                                               LFV03720
      FUNCTION IMASK (IN,IBL,IBR)                                       LFV03730
C              MASK I*2 WCRD IN OUTSIDE BITS IBL & IBR                  LFV03740
C                                                                       LFV03750
      INTEGER * 2 IN,IC                                                 LFV03760
      IO=IN                                                             LFV03770
      IF (IBR.EC.0) GO TO 50                                            LFV03780
      IT=ISHIFT(IN,IBR)                                                 LFV03790
      IO=IT                                                             LFV03800
   50 IP=ISHIFT(IO,IBL-15-IBR)                                          LFV03810
      IO=IP                                                             LFV03820
      IMASK=ISHIFT(IO,15-IBL)                                           LFV03830
      RETURN                                                            LFV03840
```

```
      END                                                          LFV03850
/*                                                                 LFV03860
//GC.SYSIN DC *                                                    LFV03870
LAMESA VILLAGE ,  4 AUG 83  1802-1819 LOCAL                        LFV03880
X CCIL AMP IN NT                                                   LFV03890
LAMESA VILLAGE ,  4 AUG 83, 1802-1819 LOCAL                        LFV03900
Y COIL AMP IN NT                                                   LFV03910
LAMESA VILLAGE ,  4 AUG 83, 1802-1819 LOCAL                        LFV03920
Z CCIL AMP IN NT                                                   LFV03930
LAMESA VILLAGE ,  4 AUG 83, 1802-1819 LOCAL                        LFV03940
TCTAL FIELD  AMP IN NT                                             LFV03950
LAMESA VILLAGE ,  4 AUG 83, 1802-1819 LOCAL                        LFV03960
X CCIL AMP IN NT                                                   LFV03970
LAMESA VILLAGE ,  4 AUG 83, 1802-1819 LOCAL                        LFV03980
Y COIL AMP IN NT                                                   LFV03990
LAMESA VILLAGE ,  4 AUG 83, 1802-1819 LOCAL                        LFV04000
Z CCIL AMP IN NT                                                   LFV04010
LAMESA VILLAGE ,  4 AUG 83, 1802-1819 LOCAL                        LFV04020
TCTAL FIELD AMP IN NT                                              LFV04030
/*                                                                 LFV04040
//GO.FT20F001 DD UNIT=3400-4,VOL=SER=LMDT3A,DISP=(CLC,KEEP),       LFV04050
//             LABEL=(1,NL,,IN),                                   LFV04060
//             DCB=(RECFM=FB,LRECL=32,BLKSIZE=512,DEN=2)           LFV04070
//GO.SYSDUMP DD SYSOUT=A                                           LFV04080
/*                                                                 LFV04090
//                                                                 LFV04100
```

APPENDIX G

COHER COMPUTER PROGRAM

```
//COHER32 JOB (2992,0165),'ANTHONY   SMC 2123',CLASS=G
//*MAIN ORG=NPGVM1.2992P,LINES=(75)
//*FORMAT PR,DDNAME=PLOT.SYSVECTR,DEST=LOCAL
// EXEC FRTXCLGP,PARM.LKED='LIST,MAP,XREF',REGION.GO=2048K
//FORT.SYSIN DD DSN=MSS.SYS3.NONIMSL.SOURCE(FOURT),DISP=SHR
//     DD *
C         THIS PROGRAM READS IN DATA FROM DIGITAL TAPES USING THE
C     SUBROUTINE RD, NORMALIZES THE DATA BETWEEN -5 AND +5 VOLTS,
C     PERFORMS A FOURIER TRANSFORM ON THE DATA INTO FREQUENCY SPACE
C     AND THEN CALCULATES THE COHERENCE OF EACH INDIVIDUAL AXIS BETWEEN
C     THE LAMESA VILLAGE AND CHEW'S RIDGE SITES.
C
      INTEGER*2 IN(16)
C       ARRAY 'IN' IS USED IN READING DATA FROM TAPE
      COMPLEX*8 XXX(8192),YYY(8192),ZZZ(8192)
      COMPLEX*8 XXL(8192),YYL(8192),ZZL(8192)
      COMPLEX*8 XXC(8192),YYC(8192),ZZC(8192)
      DIMENSION CTLX(8192),CTLY(8192),CTLZ(8192)
      DIMENSION CTCX(8192),CTCY(8192),CTCZ(8192)
      DIMENSION CTLCX(8192),CTLCY(8192),CTLCZ(8192)
      DIMENSION COHLCX(8192),COHLCY(8192),COHLCZ(8192)
C       COMPLEX*8 ARRAYS ARE USED BECAUSE COMPLEX NUMBERS ARE REQUIRED
C       BY THE FOURIER TRANSFORM SUBROUTINE 'FOURT'.
      DATA CTLX,CTLY,CTLZ/24576*0./
      DATA CTCX,CTCY,CTCZ/24576*0./
      DATA CTLCX,CTLCY,CTLCZ/24576*0./
      DATA COHLCX,COHLCY,COHLCZ/24576*0./
      DIMENSION FREQ(8192),FRQ2(8192),WORK(16384)
      INTEGER*4 ITB(12)/12*0/
      REAL*4    RTB(28)/28*0.0/
      REAL ALAB(4)/'COHX','COHY','COHZ','TOT'/
      REAL*8 TITLE(12)
      EQUIVALENCE(TITLE(1),RTB(5))
C       ARRAYS 'ITB','RTB','ALAB',AND 'TITLE' ARE USED IN GENERATING
C       THE VERTSATEC PLOTTER OUTPUT.
C    THE FOLLOWING LOOP ADVANCES THE DIGITAL TAPE BY ISEC SECONDS.
C
      ISEC=200
      ITL=ISEC*64
      DO 55 JJ=1,ITL
      CALL RD(20,IN,200,IREC,IRR)
   55 CONTINUE
      NR=19
      FNR=FLOAT(NR)
      DO 70 L1=1,NR
C       THE DO LOOP ENDING WITH STATEMENT 70 ENABLES THE PROGRAM TO
C       PROCESS A LARGE AMOUNT OF DATA BY REPEATING THE PROCESS IN
C       BLOCKS.
```

```
C        'NR' REPRESENTS THE NUMBER OF DATA SEQUENCES.                  COHO0490
C        1 SEQUENCE CURRENTLY EQUALS 8192 DATA POINTS FOR EACH CHANNEL  COHO0500
C        OR 128 SECONDS OF DATA.                                        COHO0510
C                                                                       COHO0520
C         THE DO LOOP ENDING WITH 60 READS THE DATA FROM THE PCM FRAME, COHO0530
C         STRIPS OUT THE SYNC CODE, AND SORTS OUT THE DATA BY COIL      COHO0540
C         CHANNEL. FIRST, THE NEXT THREE STATEMENTS READS THE DATA      COHO0550
C         FROM THE LAMESA SITE THAT WAS PREVIOUSLY STORED IN THE        COHO0560
C         IBM 3033 MASS STORAGE SYSTEM.                                 COHO0570
      READ(21) XXX                                                      COHO0580
      READ(21) YYY                                                      COHO0590
      READ(21) ZZZ                                                      COHO0600
C        SET THE IMAGINARY PART OF THE COMPLEX NUMBERS EQUAL TO ZERO.   COHO0610
      DO 43 I=1,8192                                                    COHO0620
      XXL(I)=REAL(XXX(I))                                               COHO0630
      YYL(I)=REAL(YYY(I))                                               COHO0640
      ZZL(I)=REAL(ZZZ(I))                                               COHO0650
   43 CONTINUE                                                          COHO0660
C        NOW READ THE CHEW'S RIDGE DATA FROM THE COMPUTER TAPE.         COHO0670
      DO 60 JJ=1,8192                                                   COHO0680
      CALL RD(20,IN,1000,IREC,IRR)                                      COHO0690
      XXC(JJ)=IN(2)                                                     COHO0700
      YYC(JJ)=IN(3)                                                     COHO0710
      ZZC(JJ)=IN(4)                                                     COHO0720
   60 CONTINUE                                                          COHO0730
      N=8192                                                            COHO0740
      FN=FLOAT(N)                                                       COHO0750
      DELTAT=1./64.                                                     COHO0760
      T=FN*DELTAT                                                       COHO0770
      DELTAF=1./T                                                       COHO0780
C     NORMALIZE THE CHEW'S RIDGE DATA BETWEEN +5 AND -5 VOLTS AND SET   COHO0790
C        THE IMAGINARY PART EQUAL TO ZERO. THE LAMESA VILLAGE DATA HAS  COHO0800
C        ALREADY BEEN NORMALIZED IN THE MASS STORAGE PROGRAM.           COHO0810
      DO 20 J=1,8192                                                    COHO0820
      XXC(J)=((XXC(J)-2048.)*5./2048.)                                  COHO0830
      XXC(J)=REAL(XXC(J))                                               COHO0840
      YYC(J)=((YYC(J)-2048.)*5./2048.)                                  COHO0850
      YYC(J)=REAL(YYC(J))                                               COHO0860
      ZZC(J)=((ZZC(J)-2048.)*5./2048.)                                  COHO0870
      ZZC(J)=REAL(ZZC(J))                                               COHO0880
   20 CONTINUE                                                          COHO0890
C        TRANSFORM THE DATA FROM ALL THREE COILS AT BOTH SITES INTO THE COHO0900
C        FREQUENCY DOMAIN.                                              COHO0910
      CALL  FOURT(XXL,N,1,-1,0,WORK)                                    COHO0920
      CALL  FOURT(YYL,N,1,-1,0,WORK)                                    COHO0930
      CALL  FOURT(ZZL,N,1,-1,0,WORK)                                    COHO0940
      CALL  FOURT(XXC,N,1,-1,0,WORK)                                    COHO0950
      CALL  FOURT(YYC,N,1,-1,0,WORK)                                    COHO0960
```

```
      CALL FOURT(ZZC,N,1,-1,0,WORK)                                     COHO0970
C       THE NEXT LCOP IS REÇUIRED AFTER TRANSFORMATICN. SEE THE WRITEUP COHO0980
C       FOR THE SLBROUTINE 'FOURT'.                                     COHO0990
      DC 40 K4=1,N                                                      COHO1000
      XXL(K4)=XXL(K4)/FN                                                COHO1010
      YYL(K4)=YYL(K4)/FN                                                COHO1020
      ZZL(K4)=ZZL(K4)/FN                                                COHO1030
      XXC(K4)=XXC(K4)/FN                                                COHO1040
      YYC(K4)=YYC(K4)/FN                                                COHO1050
      ZZC(K4)=ZZC(K4)/FN                                                COHO1060
   4C CCNTINLE                                                          COHO1070
C       THE NEXT LGOP SUMS EACH DATA SAMPLE OVER THE NR BLCCKS OF       COHO1080
C       CATA.                                                           COHO1090
      DC 30 II=1,N                                                      COHO1100
      CTLX(II)=CTLX(II)+CABS(XXL(II)*CONJG(XXL(II)))                    COHO1110
      CTLY(II)=CTLY(II)+CABS(YYL(II)*CONJG(YYL(II)))                    COHO1120
      CTLZ(II)=CTLZ(II)+CABS(ZZL(II)*CONJG(ZZL(II)))                    COHO1130
      CTCX(II)=CTCX(II)+CABS(XXC(II)*CONJG(XXC(II)))                    COHO1140
      CTCY(II)=CTCY(II)+CABS(YYC(II)*CONJG(YYC(II)))                    COHO1150
      CTCZ(II)=CTCZ(II)+CABS(ZZC(II)*CONJG(ZZC(II)))                    COHO1160
      CTLCX(II)=CTLCX(II)+CABS(XXL(II)*CONJG(XXC(II)))                  COHO1170
      CTLCY(II)=CTLCY(II)+CABS(YYL(II)*CONJG(YYC(II)))                  COHO1180
      CTLCZ(II)=CTLCZ(II)+CABS(ZZL(II)*CONJG(ZZC(II)))                  COHO1190
   3C CCNTINUE                                                          COHO1200
C       NOW GO BACK AND GET THE NEXT BLOCK OF DATA AND PERFORM THE SAME COHO1210
C       ANALYSIS CN IT.                                                 COHO1220
   7C CCNTINLE                                                          COHO1230
C       CALCULATE THE COHERENCE OF EACH COIL AND THE FREQUENCY SCALE    COHO1240
C       (LOG) IT IS PLOTTED AGAINST.                                    COHO1250
      DC 44 I4=1,N                                                      COHO1260
      COHLCX(I4)=CTLCX(I4)/(SQRT(CTLX(I4))*SQRT(CTCX(I4)))              COHO1270
      COHLCY(I4)=CTLCY(I4)/(SQRT(CTLY(I4))*SQRT(CTCY(I4)))              COHO1280
      COHLCZ(I4)=CTLCZ(I4)/(SQRT(CTLZ(I4))*SQRT(CTCZ(I4)))              COHO1290
      FREQ(I4)=DELTAF*FLOAT(I4)                                         COHO1300
      FRQ2(I4)=ALCG10(FREQ(I4))                                         COHO1310
   44 CCNTINUE                                                          COHO1320
C                                                                       COHO1330
C                                                                       COHO1340
      NPTS=1./DELTAF +1.                                                COHO1350
C        'NPTS' DETERMINES NUMBER OF POINTS NECESSARY IN ORDER FOR      COHO1360
C         THE 0 TC NPTS  FREQUENCY RANGE TC BE PLCTTED.                 COHO1370
C        FOR THE FCLLOWING 'ITB' AND 'RTB' VALUES REVIEW THE WRITE-UP   COHO1380
C        FOR THE SLBROUTINE PROCEDURE 'DRAWP'.                          COHO1390
      ITB(3)=20                                                         COHO1400
      ITB(4)=8                                                          COHO1410
      ITB(7)=1                                                          COHO1420
      ITB(12)=0                                                         COHO1430
      RTB(1)=0.0                                                        COHO1440
```

```
      RTB(2)=0.0                                                        COHO1450
      RTB(3)=ALAE(1)                                                    COHO1460
      READ(5,300C)TITLE                                                 COHO1470
      CALL DRAWP(NPTS,FRQ2,COHLCX,ITB,RTB)                              COHO1480
      RTB(3)=ALAE(2)                                                    COHO1490
      READ(5,300C)TITLE                                                 COHO1500
      CALL DRAWP(NPTS,FRQ2,COHLCY,ITB,RTB)                              COHO1510
      RTB(3)=ALAE(3)                                                    COHO1520
      READ(5,300C)TITLE                                                 COHO1530
      CALL DRAWP(NPTS,FRQ2,COHLCZ,ITB,RTB)                              COHO1540
      ITB(3)=7                                                          COHO1550
      ITB(4)=5                                                          COHO1560
      ITB(12)=0                                                         COHO1570
      RTB(3)=ALAE(1)                                                    COHO1580
      READ(5,300C)TITLE                                                 COHO1590
      CALL DRAWP(NPTS,FRQ2,COHLCX,ITB,RTB)                              COHO1600
      RTB(3)=ALAE(2)                                                    COHO1610
      READ(5,3000)TITLE                                                 COHO1620
      CALL DRAWP(NPTS,FRQ2,CCHLCY,ITB,RTB)                              COHO1630
      RTB(3)=ALAE(3)                                                    COHO1640
      READ(5,3000)TITLE                                                 COHO1650
      CALL DRAWP(NPTS,FRQ2,CCHLCZ,ITE,RTB)                              COHO1660
 3000 FCRMAT(6A8)                                                       COHO1670
      STOP                                                              COHO1680
      END                                                               COHO1690
       SUBROUTINE RD(IUN,IO,IRS,IREC,IRQ)                               COHO1700
C                                                                       COHO1710
C         THIS PRCCEDURE FLRNISHED BY DR. TIM STANTCN,                  COHO1720
C         DEPARTMENT OF OCEANOGRAPHY.                                   COHO1730
C                                                                       COHO1740
C              READ DATA FROM IUN, ALLIGN , CHECK & RETURN              COHO1750
C                                                                       COHO1760
C       IUN=TAPE NUMBER, EG 20                                          COHO1770
C       IO=INTEGER*2 ARRAY, 16 LONG,(VALUES 0-4095, SLBTRACT 2048)*5    COHO1780
C                /2028.  GIVES VOLTAGE                                  COHO1790
C       IRS= NUMBER OF RESINCS ALLOWED (ERRORS)                         COHO1800
C       IREC= COLNTER OF RECORDS (FRAMES CF DATA)                       COHO1810
C           BLOCK 512 BITS,   32 BITS = RECORD                          COHO1820
C           800 BPI TAPE UNLABLED                                       COHO1830
C       IRQ= NUMEER OF ACTUAL RESINCS (ERRORS)                          COHO1840
C                                                                       COHO1850
C                                                                       COHO1860
       INTEGER * 2 IO(16),IP(16)                                        COHO1870
       CATA IRR /C/                                                     COHO1880
       IF (IREC.EQ.0) IS=0                                              COHO1890
       IER=0                                                            COHO1900
 20    FORMAT (16A2)                                                    COHO1910
       IF (IS.NE.0) GO TO 50                                            COHO1920
```

```
      READ (IUN,20,END=900) IP                                          COHO1930
      IREC=IREC+1                                                       COHO1940
 40   IS=IS+1                                                           COHO1950
      IF (IS.LT.17) GO TO 50                                            COHO1960
      READ (IUN,20,END=900) IP                                          COHO1970
      IS=1                                                              COHO1980
      IREC=IREC+1                                                       COHO1990
 50   ICH=IMASK(IP(IS),3,0)+1                                           COHO2000
C     WRITE (6,55) ICH,IS,IUN,IREC                                      COHO2010
 55   FORMAT ('  RESYNCING ICH,IS,IUN,IREC ',4I8)                       COHO2020
C                                                                       COHO2030
      IF (ICH.NE.1) GO TO 40                                            COHO2040
      DO 100 I=1,16                                                     COHO2050
      IO(I)=ISHIFT(IP(IS),4)                                            COHO2060
      ICH=IMASK(IP(IS),3,0)+1                                           COHO2070
      IF (ICH.EQ.1) GO TO 80                                            COHO2080
      IER=IER+1                                                         COHO2090
      WRITE (6,70)  IUN,IREC ,I,ICH,IER                                 COHO2100
 70   FORMAT (' UNIT ',I3,' RECORD ',I6,'CHAN & DATA CH ',2I4,          COHO2110
     $ 'ERRORS ',I7)                                                    COHO2120
 80   IS=IS+1                                                           COHO2130
      IF (IS.LT.17) GO TO 100                                           COHO2140
      READ (IUN,20,END=900) IP                                          COHO2150
      IS=1                                                              COHO2160
      IREC=IREC+1                                                       COHO2170
 100  CONTINUE                                                          COHO2180
C                                                                       COHO2190
      IF (IER.EQ.0) GO TO 150                                           COHO2200
      IRR=IRR+1                                                         COHO2210
      IF (IRR.LT.IRS) GO TO 120                                         COHO2220
      WRITE (6,110)                                                     COHO2230
 110  FORMAT ('1 STOPPED IN SUB RD BECAUSE OF IRR.GT.',I6,' AT L110')   COHO2240
      IRQ=IRR                                                           COHO2250
      STOP                                                              COHO2260
 120  CONTINUE                                                          COHO2270
      WRITE (6,130) IREC,IRR                                            COHO2280
 130  FORMAT (' RESYNC AT FRAME ',I6,' WITH TOTAL ERRORS ',I7)          COHO2290
      IER=0                                                             COHO2300
      IRQ=IRR                                                           COHO2310
      GO TO 50                                                          COHO2320
 150  CONTINUE                                                          COHO2330
      RETURN                                                            COHO2340
 900  WRITE (6,910) IUN,IREC                                            COHO2350
 910  FORMAT ('1   END OF UNIT ',I3,' AT REC ',I7)                      COHO2360
      STOP                                                              COHO2370
      END                                                               COHO2380
C                                                                       COHO2390
      FUNCTION ISHIFT (IN,NPLC)                                         COHO2400
```

```
C                 RETURNS SHIFTED VALUE OF I*2 WORD IN                COHO2410
C                 -VE LEFT,+VE RIGHT SHIFT                            COHO2420
C                                                                     COHO2430
      INTEGER * 2 IN                                                  COHO2440
      IP=IN                                                           COHO2450
      IF (IP.LT.0) IP=IP+65536                                        COHO2460
      IF (NPLC.LT.0) GC TC 30                                         COHO2470
      ISHIFT=IP/(2**IABS(NPLC))                                       COHO2480
      RETURN                                                          COHO2490
 30   ISHIFT=IP*(2**IABS(NPLC))                                       COHO2500
      IF (ISHIFT.GT.65535) ISHIFT=MOD(ISHIFT,65536)                   COHO2510
      RETURN                                                          COHO2520
      END                                                             COHO2530
      FUNCTION  IMASK ( IN,IBL,IBR)                                   COHO2540
C                 MASK I*2 WCRD IN OUTSIDE BITS  IBL & IBR            COHO2550
C                                                                     COHO2560
      INTEGER * 2 IN,IC                                               COHO2570
      IO=IN                                                           COHO2580
      IF (IBR.EQ.0) GO TO 50                                          COHO2590
      IT=ISHIFT(IN,IBR)                                               COHO2600
      IO=IT                                                           COHO2610
 50   IP=ISHIFT(IO,IBL-15-IBR)                                        COHO2620
      IO=IP                                                           COHO2630
      IMASK=ISHIFT(IO,15-IBL)                                         COHO2640
      RETURN                                                          COHO2650
      END                                                             COHO2660
/*                                                                    COHO2670
//GO.SYSIN DC *                                                       COHO2680
LAMESA-CHEW'S RICGE,4 AUG 83, 1700-1740 LCCAL                         COHO2690
X CCIL  COHERENCE                                                     COHO2700
LAMESA-CHEW'S RICGE,4 AUG 83, 1700-1740 LCCAL                         COHO2710
Y COIL  COHERENCE                                                     COHO2720
LAMESA-CHEW'S RICGE,4 AUG 83, 1700-1740 LOCAL                         COHO2730
Z CCIL  COHERENCE                                                     COHO2740
LAMESA-CHEW'S RICGE, 4 AUG 83, 1700-1740 LOCAL                        COHO2750
X CCIL  COHERENCE                                                     COHO2760
LAMESA-CHEW'S RICGE,4 AUG 83,  1700-1740 LOCAL                        COHO2770
Y CCIL  COHERENCE                                                     COHO2780
LAMESA-CHEW'S RICGE,4 AUG 83,  1700-1740 LOCAL                        COHO2790
Z COIL  COHERENCE                                                     COHO2800
/*                                                                    COHO2810
//GO.FT20F001 DD LNIT=3400-4,VOL=SER=CRDT3,DISP=(OLC,KEEP),           COHO2820
//             LABEL=(1,NL,,IN),                                      COHO2830
//             DCE=(RECFM=FB,LRECL=32,BLKSIZE=512,DEN=2)              COHO2840
//GO.FT21F001 DD LNIT=3330V,MSVGP=PUB4A,DISP=(OLC,KEEP),              COHO2850
//             DSN=MSS.S2992.LMDT3D,                                  COHO2860
//             DCB=(RECFM=VBS,BLKSIZE=4096,LRECL=4092)                COHO2870
//GO.SYSDUMP DD SYSOUT=A                                              COHO2880
```

```
/*                                                                      COHO2890
//                                                                      COHO2900
```

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